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SCIENCE, NATURAL AND SOCIAL

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SCIENCE, in the more restricted sense in which it is normally employed in English-speaking countries, is that activity by which to-day we attain the great bulk of our knowledge of and control over the facts of nature. This activity, like other human activities, has developed and evolved, and by no means all the stages in its evolution have merited the title of scientific. In remote prehistoric times, our early ancestors worked by trial and error combined with simple, intuitive common sense. This prescientific approach, however, was combined with the non-scientific methods of control that we call magic, and equally non-scientific rationalizations in the field of explanation. But science in this phase was still, to our modern view, unscientific in two major aspects—it was traditional and it was esoteric. Scientific knowledge was confined to a limited group among the priesthood, and it was cast in a mould of tradition which rendered change and progress slow. Being associated with the priesthood, it was also intimately bound up with non-scientific practice and non-scientific interpretation—magic and theology.

After some three or four millennia, the Greeks suddenly burst free of the prison of secrecy and traditionalism and proclaimed the freedom of intellectual inquiry. The "birth of science" is usually dated from them, but the assumption is only a half-truth. At best it was the acquisition of freedom and self-consciousness by the scientific spirit, not the emergence of a wholly new activity to be called science. And in the second place, the type of science which it inaugurated differed radically from modern science in several respects. It was almost entirely divorced from industry and practical application; it was exceedingly speculative and did not lay the same stress on experimental verification as we do; and, correlated with this, it had not invented the modern methodology of publication of the data and methods used, as well as the conclusions reached.

A few centuries later, the combination of Greek intellect and ingenuity with the practical spirit of the Roman imperium made Alexandrian science something much more like modern science in outlook and methods of working. But this was swallowed up in the anti-scientific Christian flood and the general collapse of Roman civilization.

During the Dark Ages in the west, the Arabs kept the scientific spirit alive, and by means of their mathematical inventions paved the way for immense improvements in the technique of scientific research.

Natural science, in its modern form, can fairly be said to date back no further than the seventeenth century. With Bacon as its St. John the Baptist, it developed its gospel and its ministry. Curiosity for its own sake, but also interest in industrial techniques and practical control; freedom of inquiry; experimen-

tal verification in place of authority; full publication and abundant discussion —with these a truly new phase was inaugurated.

To-day it seems that we are again in the process of launching a new phase of science—one in which social as well as natural phenomena are to be made amenable to scientific understanding and rational control.

As with natural science, social science too has had its earlier stages. It too passed through the stage of trial and error, in which social organization shaped itself under the influence of unconscious adjustment together with non-rational rules of conduct and non-scientific interpretations of human destiny. It also had its traditional phases, often tightly bound up with philosophical and theological interpretative principles, as, for example, in the climax of the Middle Ages. And it has had its birth of free speculative inquiry, parallel to the Greek phase of natural science—but two thousand years later, in the philosophers of the seventeenth and especially the eighteenth century.

Finally, its modern stage now dawning has had, like the modern stage of natural science, its scattered precursors, its Roger Bacons and Leonardos—and it has had its precursor in the restricted sense, its equivalent of Francis Bacon in the Renaissance. Many, I am sure, would put Herbert Spencer in this position; but I believe that the true John the Baptist of social science is Karl Marx. Herbert Spencer, for all his academic knowledge—or perhaps because of it, was more in the position of an Old Testament prophet. His work was essentially analogical. He demonstrated that social science was an inevitable development; but his notions of what form it would actually take and what methods it should employ were vague and essentially erroneous.

Marx, on the other hand, developed a system directly based on social facts and directly applicable to them. He did not just prophesy *a* Messiah; he indicated *the* Messiah. As natural scientists tend to undervalue Bacon because he himself did not make discoveries or work out experimental techniques, so social scientists tend to underrate Marx because his system is a dialectical one, ready-made and complete with answer to any problem, not sufficiently empirical and inductive for their scientific taste. But at least Marx, like Bacon, gave expression to a new outlook and a new method of attack, and helped materially to alter the intellectual climate so as to make it propitious for scientific work in his field.

The question immediately poses itself as to why the emergence of social science into large-scale and efficient operation has been so long delayed. The triumphs of natural science both in discovering radically new knowledge and in applying it practically to satisfy human needs have been so spectacular and so fruitful that it would seem natural and obvious to extend the same methods to the field of social phenomena.

The answer is a very simple one: the methods are *not* the same. The scientific spirit remains unaltered whether it is contemplating a nebula or a baby, a field of wheat or a trades union. But the methodology of social science is inevitably different from that of natural science. It is different and must be different for one basic reason—the investigator is inside instead of outside his material. Man can not investigate man by the same methods by which he investigates external nature. He can use the methods of natural science to investigate certain aspects of man—the structure and working of his body, for instance, or the mode of his heredity; but that is because these are shared with other organisms and because they are partial aspects which can be readily externalized. But when he starts investigating human motive, his own motives are in-

volved; when he studies human society, he is himself part of a social structure.

What consequences does this basic difference imply? In the first place, man must here be his own guinea-pig. But this is impossible in the strict sense, for he is unable to make fully controlled experiments. Even if an absolute despot were to subject a group of people to rigorous experimentation—by depriving them of alcohol, for instance, or by adopting a new form of education—the results would have only a limited application. The smallness of the group, the compulsion involved, the inevitable limitations on the contacts and full social activity of the group, would make it impossible to apply the results directly to an entire normal society, however regimented. And the difficulties are of course enormously greater in any free society.

A second, more technical difficulty is in a sense a consequence of the first. Causation in social science is never simple and single as in physics or biology, but always multiple and complex. It is of course true that one-to-one causation is an artificial affair, only to be unearthed by isolating phenomena from their total background. None the less, this method is the most powerful weapon in the armory of natural science: it disentangles the chaotic field of influence and reduces it to a series of single causes, each of which can then be given due weight when the isolates are put back into their natural interrelatedness, or when they are deliberately combined into new complexes unknown in nature.

This method of analysis is impossible in social science. Multiple causation here is irreducible. The difficulty is a twofold one. In the first place, the human mind is always looking for single causes for phenomena. The very idea of multiple causation is not only difficult, but definitely antipathetic. And secondly, even when the social scientist has overcome this resistance, extreme practical difficulties remain. Somehow he must disentangle the single causes from the multiple field of which they form an unseparable part. And for this a new technique is necessary.

Next, and in many ways even more important than the first two together, comes the question of bias. Under this head I include anything appertaining to the investigator which may deflect his scientific judgment. It is the equivalent of experimental and observational error in natural science. In natural science, there are statistical methods for discounting both sampling error and personal error; the limits of accurate measurement are determined for different types of instrument; the procedure of controlled experimentation has been reduced to a fine art. The procedure of the discounting of error in natural science by these procedures has proved difficult enough. But to discover how to discount bias in social science is proving very much harder.

Then there is the inherent genetic bias imposed by his own temperament. For certain purposes, investigators in social science are their own instruments to a very great extent and in a way unknown in natural science—and the instruments differ in their very construction.

Next we have the bias introduced by the peculiar psychological development of human beings. They can only resolve their inevitable conflicts during childhood and adolescence by relegating a great deal to their unconscious, whether by the psychological mechanism of suppression or that of repression. Roughly speaking, the former introduces bias by leaving gaps in a person's knowledge and outlook, whereas in the latter the gaps are accompanied by strong emotional distortions and resistances. The scientific study of sex, for instance, has been much retarded by repressional bias—witness the reception originally given to Havelock Ellis's great work and the extraordinary resistance still offered to Freud's ideas.

Bias of this type has the additional danger that those who make an effort to discount it may readily swing into over-compensation—a bias of opposite sign. The investigator whose youth was tormented by intolerant religion is apt to discount the social importance of religion far too much; the convert to Freudian methods is liable, in discounting his own early sexual repressions, to underestimate the social value of repression in general.

Bias has also been encountered in natural science, but only when its findings come up against emotionally held convictions—only, that is, when it has had social entanglements. We may cite the prohibition of anatomical dissection, the proscription of Galileo's findings, the hostility to the Darwinian theory, the Nazi distortion of racial anthropology, the Soviet attack on modern genetics. The present course of general anti-scientific feeling, so noticeable during the past decade, has been due in part to a general feeling that scientific findings, by sapping the traditional view of man's place in the universe and in society, are undermining the basis of ordered society.

Finally, there comes the most fundamental difference of all. Values are deliberately excluded from the purview of natural science: values and all that they connote of motive, emotion, qualitative hierarchy and the rest constitute some of the most important data with which the social scientist must deal. But how can science deal with them? Science must aim at quantitative treatment: how can it deal with the irreducible absolutes of quality? Science must be morally neutral and dispassionate: how can the social scientist handle the ethical bases of morality, the motives of passion?

Let us be frank with ourselves. There is a sense in which, because of this qualitative difference between its data and those of natural science, social science can never become fully and vigorously scientific. To understand and describe a system involving values is impossible without some judgment of values, and still more impossible without such value-judgment is the other scientific function, that of control.

However, this is not quite so serious as at first sight appears. Even in natural science, regarded as pure knowledge, one value-judgment is implicit—*belief in the value of truth.* And where natural science passes into control, a whole scale of values is involved. The application of natural science is guided by considerations of utility—utility for profit, for war, for food-production, for health, for amusement, for education. The application of science through the instrument of *laissez-faire* economic systems has brought us to a position at which we are being forcibly reminded that these different utilities may conflict.

Thus, rather crudely, we may say that in respect of the problem of values, social science in its aspect of knowledge is faced by the same difficulties as is natural science in its aspect of control. The difficulty is thus in a sense an artificial one. Its consideration has reminded us that natural science is not such a pure disembodied activity as is often assumed. Language is in part responsible for the assumption. There is no such thing as natural science *per se.* The phrase is a shorthand description of those activities of human beings which are concerned with understanding and controlling their natural environment. And, just as simple one-to-one causation is a fiction, only approximated to in artificially isolated systems, so the emancipation of natural science from considerations of value is a fiction, approximated to by the possibility of temporarily and artificially isolating scientific activity from other human activities.

In regard to multiple causation, we may look forward to an extended use of techniques of mathematical correlation. These have already been developed to a high pitch for dealing with problems of

multiple causation in physical science, and special methods have been worked out by Spearman and his school for dealing with psychological questions. The use of probability methods is also indicated. Here again, these have been developed to a high pitch for use in natural science. Mathematical methods also enter into another technique which is now being rapidly developed in social science, that of the questionnaire, and especially the set of questions asked by the trained interviewer. The questionnaire method is widely used, but the reluctance or inability of large sections of the public to fill its elaborate forms restricts its sphere and impairs its sampling accuracy. The success of the method in this form depends chiefly on two things—the proper framing of the questions and the obtaining of a truly representative sample of the population to answer them.

Some questions do not admit of a significant answer, or any answer at all; others will defeat their own ends by influencing the form of the answer. In any case, the method of questioning a representative sample of a large population can only be applied to a restricted set of problems, though within limitations it may become extremely efficient. In one field, that of the straw ballot, it is developing such uncanny accuracy that it is infringing upon practical politics. Some people are asking whether a properly conducted straw ballot could not be profitably substituted for the trouble and expense of a full election; while others feel that the announcement of a straw vote may itself influence the course of the subsequent election.

The method of mass observation constitutes an attempt to attain objective information on various aspects of public opinion and behavior which elude the method of yes-and-no questioning. Inquiries may concern the reaction of the public to a particular place, like the Zoo or the National Gallery; to a particular event, like the Coronation; to a particular activity, such as smoking or the time of rising; or to a general situation, like that of war. In some cases, composite pictures which could have been obtained in no other way have resulted from the use of this method. But in general its technique, both as regards sampling and questioning, will have to be refined a good deal before it can claim to be scientifically dependable.

Joint work is on the increase in natural science, but here largely because of the quantitative burden of routine procedures in subjects like bio-chemistry or genetics. We may distinguish such work as group work. The term group is here used in the sense of a body of people pooling their different knowledges and skills to cope with qualitatively differentiated problems. Group work in this sense is also to be found when geneticists, ecologists and statisticians make a united attack on some problem of microevolution, or an embryologist and a biochemist combine to study development. But it is far more necessary in social science.

It may be expected that the working out of various techniques made necessary by the nature of the data of social science will have fruitful repercussions in certain fields of natural science, such as evolution and comparative biological study in general, where the present bias in favor of experimental work and specific results is leaving vast bodies of published data awaiting the synthetic treatment which only organized group attack can provide.

I have already mentioned certain substitutes for the controlled experimentation of the natural sciences. But experimentation as a method is not ruled out in social science, though it must take different forms. Regional or group experimentation is the most obvious method. Two regions or groups are chosen which are as similar as possible, and certain measures are introduced in the one, while the other serves as control. The Carlisle

experiment on liquor control in Britain was an early essay in this method, but unfortunately it has been allowed to drag on without any serious attempts to draw theoretical conclusions or to frame practical policies on the basis of its operation. The T.V.A. in America is perhaps the largest social experiment ever undertaken, at any rate in a non-totalitarian country. The area involved, however, is so large that strict controls are difficult to find.

As the spirit of scientific planning extends with government, we may expect to see regional experiments tried out in many fields. Medical and health services would afford another excellent field. The social results of cheap electric power could be made the subject of local experiments much more rigorous than that of the T.V.A.

The fact that in social science man is his own guinea-pig has a number of methodological consequences, both for social science research and for its practical applications. The social scientist often requires true cooperation from his material in the sense of understanding of the reason for his work and voluntary participation in its course. Education as a social experiment can never succeed without properly equipped teachers, specially trained in pedagogy. The interview method will give entirely misleading results without interviewers skilled in the technique of their job.

There remains the question of bias. In this there is no ready method to hand. It took generations for natural science to work the technique of discounting experimental and observational error; it will take generations for social science to work out that of discounting the errors due to bias. The first step is obviously to make the world aware of the existence of bias and of the need for its discounting. Where human affairs are still handled in a pre-scientific spirit, bias is apt to play a very large practical role, especially the bias in favor of one's own group, whether class, religion or race. Such bias produces powerful rationalizations, which are then used to justify policies of the merest self-interest. The enslavement of Negroes was justified on the basis of the scriptural authority for the mental destiny of the sons of Ham; the brutalities of the Nazi persecution of Jews, on the racial superiority of "Aryans." The group bias of the prosperous classes in early nineteenth-century England appeared in astonishing assertions about the inherent inferiority of "the poor"; the same bias is evident in certain aspects of the eugenics movement to-day.

Another wide-spread and disastrous form of bias arises from psychological conflict and tension. Censoriousness in respect of moral taboos, the desire to see the infliction of vindictive punishment, the unconscious reluctance of many parents to see the harsh school discipline under which they suffered replaced by humaner methods, the emotional basis of militarism—all these and many other undesirable determiners of human conduct are the result of bias arising from repression or emotional conflict and the inflicting of lasting distortion on the psyche.

But even in scientific circles bias may play a surprisingly large part. A good example was the resistance of the great majority of medical men during the early part of the last war to admitting any cause for breakdown among soldiers save physical shell-shock and malingering. And the uncritical assumption, even among scrupulously careful persons, that differences in intelligence between social classes were genetic and not due to nutrition or other social factors, is another. Again, we have the thesis of anthropologists, like Levy Bruhl, that savage mentality is in some way qualitatively different from and inferior to our own, whereas it is in fact essentially similar, but operating in different material and social conditions.

Voices are still raised proclaiming that social science is a contradiction in terms, that human affairs are not intrinsically amenable to the scientific method. Those who hold this opinion are, I believe, wrong. They are confusing the methods of natural science with scientific method in general. Social science differs inevitably from natural science in many important respects, notably in its lesser capacity for isolating problems, and more generally in its lesser degree of isolation from other aspects of human activity and its consequent greater entanglement with problems of value. It must therefore work out its own technique and its own methodology, just as natural science had to do after Bacon and the eager amateurs of the seventeenth century had glimpsed natural science as a new form of human activity.

Let us not forget that the working out of this technique and this methodology by natural science took a great deal of time and is indeed still progressing. During the growth of modern science, the amateur has been largely replaced by the professional; university laboratories have been supplemented by governmental and industrial institutions; whole-time research has become a new profession; the team has in many types of work replaced the individual; cooperative group work is beginning; and the large-scale planning of research is in the offing.

Finally, the enormous growth of applied science has had effects of the utmost importance on pure research. It has done so partly by providing new instruments which would otherwise have been unavailable; one need only instance the gifts of the wireless industry not only to pure physics but to such unexpected branches of science as nervous physiology. And partly by suggesting new lines of research, the needs of wireless have again revealed new facts concerning the upper atmosphere, while the study of plant pests and human diseases has brought to light new modes of evolution.

We need have no fear for the future of social science. It too will pass through similar phases from its present infancy. By the time that the profession of social science, pure and applied, includes as many men and women as are now engaged in natural science, it will have solved its major problems, of new methods, and the results it has achieved will have altered the whole intellectual climate. As the barber-surgeon of the Middle Ages has given place to the medical man of to-day, with his elaborate scientific training, so the essentially amateur politician and administrator of to-day will have been replaced by a new type of professional man, with specialized training. Life will go on against a background of social science. Society will have begun to develop a brain.

The Biological Analogy

Writers and philosophers have often attempted to illuminate human affairs by means of biological analogies. Shakespeare, in Coriolanus, drew the analogy between the human body and the body politic in Menenius' speech on the body and its members. Herbert Spencer's code is shot through with the premise that human biology is but an extension of biology *sensu stricto*, and that, accordingly, biological analogies will in general have validity. Various German philosophers during the latter half of the past century justified war on the basis of the Darwinian conception of the struggle for existence, and the apostles of *laissez-faire* in Britain found support for economic individualism in the same doctrine. Socialists, on the other hand, have pointed to the fact of mutual aid in nature, as set forth by Kropotkin. Analogies with the social organization of ants and bees have been used, according to taste and prejudice, to glorify or to attack the doctrines of human collectivism. The Marxist thesis of progress

being achieved through a reconciliation of opposites, only to lead to a new antithesis, which in turn paves the way for a new synthesis, is customarily documented in the works of communist philosophers by examples from biological evolution.

It is interesting to ask ourselves precisely what validity resides in this method of extending biological principles by analogy into human affairs. At the outset, it is clear that analogy, unless applied with the greatest caution, is a dangerous tool. This is clear to the modern scientist, but it has not always been so. Indeed, to put too great a burden on the back of analogy is a fundamental temptation of the human mind, and is at the base of the most unscientific practices and beliefs, including almost all magical ritual and much of supernaturalist superstition. During the last millennium, moralists, theologians and scholastic philosophers have often regarded analogy, even of the most far-fetched kind, as the equivalent of proof.

Has analogy, then, no part to play in scientific thought? Far from it. Analogy is in the majority of cases the clue which guides the scientific explorer towards radically new discoveries, the light which serves as first indication of a distant region habitable by thought. The analogy with waves in water guided physics to the classical wave-theory of light. The analogy with human competition, after playing an important role in Darwinian theory (did not Darwin arrive at the theory of natural selection from his reading of Malthus?) was transferred by Wilhelm Roux to a smaller sphere, the struggle of the parts within the individual.

But analogy may very readily mislead. Weismann sought to apply this same analogy of intra-organismal struggle and selection to the units of heredity; but the analogy happens not to hold good. The analogy of a stream of particles misled Newton as to the nature of light.

Analogy thus provides clues, but they may easily be false clues; it provides light, but the light may be a will-of-the-wisp. However pretty, however seductive, analogy remains analogy and never constitutes proof. It throws out suggestions, which must be tested before we can speak of demonstration.

But if non-scientists often overrate the importance of analogy, scientists themselves tend to be over-cautious and to underrate its potential value. Its value is especially great when the analogy is one between closely related subjects. The analogy between the evolution of different groups of animals is often surprisingly close, for the simple reason that both the material and the conditions are essentially similar throughout. None the less, unpredictable results are not infrequent. The adaptive radiation of the marsupials in Australia was in its broad lines similar to that of the placentals in the rest of the world; but the placentals never developed large jumpers like the kangaroo, and, correspondingly, the marsupials produced no quick runners like horse or antelope, and no freshwater fish-eaters like the otter. Again, the parallelism in the social evolution of the quite unrelated ants and termites is truly astonishing; yet the termites have never produced grain-storers or slave-makers, while the ants have no system of second-grade queens in reserve.

One further caveat before we pursue the biological analysis of man's social existence. Human societies, though indubitably organic, are unlike any animal organism in the mode of their reproduction. Strictly speaking, they do not usually reproduce at all, but merely perpetuate themselves. They exhibit no process of fertilization between living gametes, no distinction between mortal body and immortal germ-plasm. They continue indefinitely by the aggregate reproduction of their component individuals. In their development, change of structural and functional pattern can

be dissociated from growth in a way impossible to a developing animal, and social heredity operates via cultural transmission, not by the physical transmission of material potencies of development. On the other hand, the separation of phylogeny and ontogeny, the development of the race and the development of the individual, which is so evident in higher animals, is blurred in social development to such an extent that the two often coincide.

All analogies between the birth, development and death of civilizations or nations and of animal organisms must be very heavily discounted because of the fundamental difference in mode of their reproduction and inheritance.

Now, with these facts in mind, let us look at some of the biological analogies that lie near to hand. In the first place, there is the analogy between the societies of insects and those of man. This, however obvious and however often applied, must be rejected out of hand. The two rest on different bases—those of ants, bees and termites on the fixity of instinct, those of man on the plasticity of intelligence. For this reason man can not and will not ever develop specialized castes, with functions predetermined by heredity, nor will human society ever work with the machine-like smoothness of an ant-hill or a termitary. Furthermore, we must not expect that in man the altruistic instincts will ever become predominant: as Haldane has demonstrated, this can only occur when neuter castes of workers or soldiers exist. Altruism in man must be fostered by education and given fuller play by appropriate social machinery; it can not be implanted once and for all by heredity.

The next analogy to be considered is that between the body of a higher animal and human society. This has taken two main forms. In the one, the analogy is drawn between the main classes of society and the main organ-systems of the body, or, going a little further into detail, between the specialized functions of various agencies of social existence—trade, government, war, education and so forth—and those of particular bodily organs. In the other, which has been attempted only since the discovery of the cell and the rise of the cell-theory, the cell within the body is compared to the individual within society. An extension of this second analogy bridges the gap between it and the first: instead of the individual cell, attention is concentrated on the different types of cells and the different resultant tissues of the body; and these, rather than the still more complex organs, each composed of numerous tissues, are compared with the various specialized trades and professions in human society.

In assessing the value and limitations of these analyses, we must begin by recalling the basic difference btween the animal body and human society, namely, the far greater subordination of the parts to the whole in the former. This is especially important for the comparison between cells and human individuals. The difference here is the same basic one as that between the castes of a social insect society and the specialized aptitudes of human beings, but pushed to a much greater length. The cells of the body are irrevocably specialized during early development, and their specialization is far greater than that between even a queen and a soldier termite. Without the aid of embryological study, no one could guess that a nerve-cell, with its long nerve-fiber and its branching dendrites, a sperm, with condensed head and motile tail, and a fat-cell, an inert lump crowded with globules of reserve fat-stores, were all modifications of a single common type. Altruism, in the sense of sacrifice of the unit for the good of the whole, has also been carried to a much higher pitch. As with drone bees, only one out of many sperms can ever perform its fertilizing function; the ratio is one to many tens of millions, instead

of one to a few hundreds. The cells of the outer skin have no other function than to be converted into dead horny plates, constantly shed and as constantly renewed; the red blood-cells lose their nuclei before being capable of exerting their oxygen-carrying function, and have a life much more limited even than that of worker bees. Units may even be pooled. The giant nerve-fibers of cuttlefish are the joint product of numerous united nerve-cells; our own striped muscle-fibers are vast super-units, comparable to a permanently united tug of war team.

In terms of biologically higher and lower, there is thus a radical difference between cells and human beings. Both are biological individuals which form part of more complex individualities. Cells are first-order individuals, bodies second order ones and human societies, like hydroid colonies or bee-hives, third-order ones. But whereas the individuality of the body of higher animal, cuttlefish, insect or vertebrate is far more developed than that of its constituent cells, that of a human society is far less so than that of its individual units.

This fact, while it makes the analogy between cell and human individual almost worthless, is of great value itself as a biological analogy, since it immediately exposes the fallacy of all social theories, like those of Fascism and National Socialism, which exalt the state above the individual.

A book could be written on the subject of analogies between biological organisms and society. One with peculiar relevance to-day is the tendency, repeated over and over again in evolution, for types to specialize on the development of brute strength coupled with formidable offensive or defensive weapons, only to be superseded by other types which had concentrated on efficiency of general organization, and especially on the efficiency of the brain. The outstanding example is the supersession of the formidable reptiles of the late Mesozoic by the apparently insignificant mammals of the period.

This phenomenon is often somewhat misinterpreted as the replacement of specialized by generalized types. There is an element of truth in this idea, but the fact is often lost sight of that the successful generalized type always owes its success to some improvement in basic organization. Such improvements in general organization are specializations, but they are all-round specializations, whereas what are usually called specializations are one-sided. This distinction contains the kernel of what is probably the most important of our biological analogies—the analogy concerning desirable and undesirable directions of change.

A detailed analysis of type of evolutionary change shows that some of them can legitimately be called progressive, in the sense that they constitute part of a steady advance on the part of living matter towards a greater control over and independence of its environment. Only a small and steadily diminishing fraction of life participates in progressive change.

Each step in progress is constituted by all-round specialization—an improvement in general organization; one-sided specialization always leads into an evolutionary blind alley.

Here I have only space to mention the two types of change which have been most important in the later phases of evolutionary progress. One is the development of mechanisms for regulating the internal environment of an animal, and so making it more largely independent of changes in external environment or better able to pass from one type of activity to another. The other is the improvement of the mechanisms for obtaining and utilizing knowledge of the environment, which in its later stages, after the efficiency of sense-organs had reached its limit, has been brought about by improvement in brain mechanism.

The biological analogy to social affairs is obvious. It provides the most abundant justification for the abandonment of *laissez-faire* in favor of social and economic planning: but the planning must be designed to give society an internal environment which shall be both stable in essentials and flexible in detail, and to enable it to undertake the greatest diversity of functions with the least dislocation.

The biological analogy from brain evolution is, however, even more illuminating. As animal evolution continued, the avenues of progress were cut off one by one. Changes that had been progressive in their time were exploited to the full and reached the limit of their potentialities. Mere bulk of body had reached its limit in the dinosaurs during the Mesozoic, some sixty million years ago. Ten or twenty million years later temperature regulation in certain animal forms had been perfected. The exploitation of the insectan type of social life by ants was over about twenty-five millions years back, and ants have not evolved since.

Similarly, the number of the groups which might share in progressive change steadily narrowed down. Groups like the echinoderms were soon eliminated owing to their headlessness; then the great phylum of molluscs, through defects in general organization; then the insects, through their limited size. Only the vertebrates remained. The cold-blooded forms were eliminated by the biological invention of temperature regulation; the birds, by their over-specialization for flight; the marsupials, by their greatly inferior reproductive mechanism. Among the placentals, now sole repositories of potential advance, the majority of lines cut themselves off from progress by one-sided specialization. Only the arboreal primates escaped, since their mode of life left teeth and limbs unspecialized, while demanding greater efficiency in the highest sense of all, vision, and greater correlation between hand and eye. This correlation meant improvement in brain structure, which split over in the form of increased educability and awareness. Finally, all the primate lines but one wandered into blind alleys, becoming over-specialized for tree life. Only the one stock which early redescended to the ground and concentrated on all-round adaptability remained potentially progressive—man. The human species has now become the only branch of life in which and by which further substantial evolutionary progress can possibly be realized. And it has achieved this enviable, but at the same time intensely responsible, position solely by concentrating on brain as against other organs as its line of specialization.

This evolution of brain, as the one inexhaustible or at least unexhausted source of progress, thus demands our closest attention as a biological analogy for social affairs. With some simplification, the process of brain evolution in vertebrates is resolvable into two main steps—first, the addition of two centers of correlation in different parts of the brain, one for the correlation of sensory knowledge, the other for the correlation of action: and of course the two centers were united by communicating cables. This is the stage arrived at in fish. The next step was the provision of a further wholly new center of correlation, superimposed on the previous mechanism. This organ of ultimate adjustment and control consists of the cerebral hemispheres, which are wholly unrepresented in the lowest vertebrates. Its essential exchange mechanism consists of the cerebral cortex. So far as we know, the cortex, in spite of all localizations and functional specializations within it, always acts as a whole, in the sense that its activity can be thought of as a complex field which is altered in its total arrangement by any alteration in any of its parts.

The final step between ape and man is marked by the great enlargement of those areas of the brain which have the least specialized function—the so-called association areas which lie between the regions wherein are localized the reception of relayed sensory information and the emission of executive messages for action. It is this, it seems, which has made possible self-consciousness and true conceptual thought.

During the course of this evolution, the cerebral hemispheres increase from zero to a mass which exceeds that of all the rest of the central nervous system taken together, and they become one of the larger organs of the body.

Our brain analogy, however, does illuminate the social problem in an extremely valuable way. In the first place, the highest stage of evolution in this respect which has as yet been reached by any society is, by biological standards, extremely primitive. It corresponds with a quite early stage in the development of cerebral hemispheres—perhaps higher than that of a fish, but certainly not beyond that found in reptiles. Before humanity can obtain on the collective level that degree of foresight, control and flexibility which on the biological level is at the disposal of human individuals, it must multiply at least ten-fold, perhaps fifty-fold, the proportion of individuals and organizations devoted to obtaining information, to planning, correlation and the flexible control of execution. The chief increases are needed in respect of correlation and planning and of social self-consciousness. In these respects, wholly new social organs must be evolved, whose nature we can only envisage in the most general terms.

In respect of planning and correlation, we can dimly perceive that some large single central organization must be superposed on the more primitive system of separate government departments and other single-function organizations; and that this, like the cerebral cortex, must be at one and the same time unified and functionally specialized. It will thus contain units concerned with particular social and economic functions, but the bulk of its personnel will be occupied in studying the interrelations between these various functions.

As regards social self-consciousness, the course of evolution must be quite different. Newspapers and books, radio, universal education—these and other points of technological and social advance have given us, in primitive form, the mechanisms needed. At the moment, however, they are being, in the light of biological analogy, largely misapplied. Education stops dead for most people in early adolescence, and concerns itself mainly with providing specialized techniques, together with a froth of obsolescent "culture." The cinema to-day is primarily an escape mechanism. Newspapers distort the balance of truth in the service of political or financial interests, and are driven by competition for advertising into sensation-mongering. The radio is as yet essentially a collection of scraps, a functional patchwork. Art as a communal function is moribund and needs to be recreated on a new social basis. Religion is in a similar position, and much of the population no longer feels its influence.

The first need is to recognize that a free country, in this increasingly complex world, can not exist, let alone find satisfaction, without being self-conscious, and all the agencies of public opinion must be moulded to this end. A self-conscious society would be one in which every individual comprehended the aims of society, his own part in the whole, the possibilities of intellectual, artistic and moral satisfaction open to him, his rôle in the collective knowledge and will. But for this, as for correlation or planned control, the most elaborate organization is required.

NATURALISTS IN THE WILDS OF BRITISH COLUMBIA

I. OUR WILDERNESS HOME AND LIFE IN WINTER

By JOHN F. and THEODORA C. STANWELL-FLETCHER

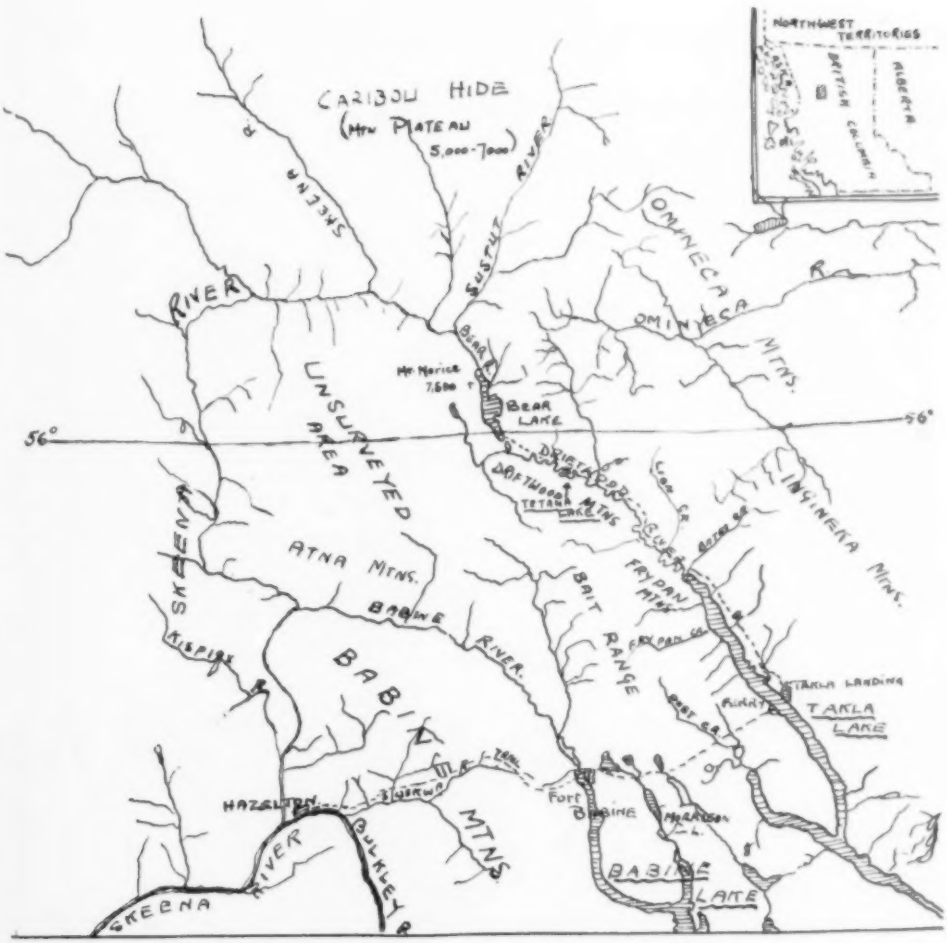
DIMOCK, PENNSYLVANIA

THE Province of British Columbia on the west coast of Canada is a land of infinite bigness, variety, wealth and beauty, and with its 372,300 square miles of territory is larger by 50,000 square miles than the combined states of Washington, Oregon and California, or approximately equal in size to the combined areas of the United Kingdom, France, Holland, Belgium and Denmark. It is over one thousand miles long from southeast to northwest and extends over eleven degrees of north latitude from forty-nine degrees to sixty degrees. There are mighty rivers and inland lakes, great mountain ranges with lofty snow-clad peaks—many still unnamed and unsurveyed—great valleys and tremendous stretches of virgin forest; a combination which gives the province of British Columbia an unrivalled variety of topography, climate and habitat. This in turn makes for a flora and fauna of unusual richness and variety.

RED SQUIRREL. WINTER.

Somewhere in the wilds of this province we had long wished to build a home where we could live a peaceful and simple life and study the flora and fauna in natural conditions throughout all the seasons. We felt the need of an existence which might lead to a greater physical and mental health than the one which was lived by most of our friends in modern towns and cities. One of us had many years of experience to his credit in the vast wilderness of far northern Canada, and we both had a fair idea of the great hardships and the great joys of life in the wilds and preferred it to any other.

Many years could well have been spent in roaming the British Columbia solitudes in search of the ideal spot, and so we were compelled to decide on at least a certain region. We chose the Driftwood River Valley, situated at about fifty-six degrees north latitude and over two hundred miles northeast of the southern tip of Alaska. It was off the beaten track and generally unknown to scientists. Mr. E. A. Preble had passed through there in July, 1913, but as far as we knew no real study had been made of the region. No doubt the presence on the map of a large area adjacent, marked "Unexplored," was a contributing factor in our choice. We had arranged with the Provincial Museum of British Columbia to send them the results of any small collections we might make. We were pleased to find that the powers-that-be in this province frowned on any large collecting expeditions from "outside" and did everything in their power to keep British Columbia material for British Columbia. This was a view-point with which we entirely sympathized, and



MAP OF THE DRIFTWOOD RIVER REGION OF BRITISH COLUMBIA
SHOWING LOCALITIES REFERRED TO IN TEXT. SCALE 30 MILES TO AN INCH APPROXIMATELY.

this policy, coupled with the isolation and difficulties of penetrating into that part of the country, should, we felt, give us a chance to live undisturbed in our beloved wilderness.

Our adventures really began at Lake Tetana in the late summer of 1937. While on the trail with guide and packhorses from Hazelton, British Columbia, we had met an old Indian at Lake Babine who told us of this small "luffly lake—not like prison," from which we judged that it was not completely hemmed in by mountains or forest, as were the many hundreds of lakes in that country. The man told us that from the lake one had a good view of the mountains around. On September 12th, after a two-weeks journey on horse-back over mountain passes and winding, overgrown trails, fording swift mountain streams and rivers, crossing mud holes and rotten log bridges, with the usual amusing and hair-raising episodes which go with a packhorse trip, we reached the mile-long lake whose Indian name, Tetana, means "Flows into the River."

It was at the time of a clear sunset,

LAKE TETANA. SEPTEMBER 1937.

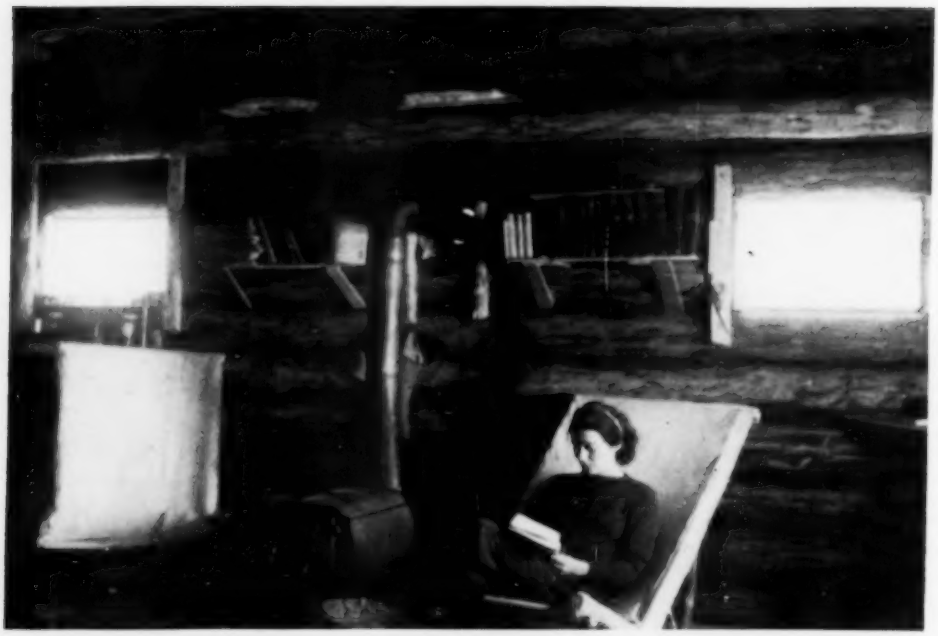
VIEW OF LAKE TETANA THROUGH CABIN FRONT DOOR. NOVEMBER 1937.

and the crystal waters of the forest-and-grass-fringed lake reflected the nearby range of Driftwood Mountains. Tinted clouds floated on the still waters and towards the south end of the lake the reflection of the Fry-Pan Mountains, rugged, snow-capped and inviting, shimmered with the motion of ducks, loons and muskrats. A coyote watched us from a curve in the lake shore not far from our camp.

Only one or two Indians who trapped in the vicinity, and practically no white men, knew or had ever seen this lake. Takla Landing, the nearest settlement, of about seventy-five people, was some sixty miles away, the nearest automobile road and electric light two hundred, and the nearest railroad farther still. At last we had our mountain solitude, and we had axes and a large saw, jack-pine trees for cabin logs and two Indian helpers. Among our supplies were three large glass windows, still unbroken after the long journey on pack-horses; medical supplies, bedding, books, cameras, binoculars, warm clothing, coal-oil lamps and oil for the long winter nights; flour and sugar by the hundreds of pounds, bacon by the slab, hams, cheeses, sacks of vegetables and cans of everything edible. Our fuel was already there, in the forest around us. We had brought two sheet-iron stoves along with us; also a drum-oven in which to bake bread, cakes, pies and biscuits.

DRIFTWOOD RIVER SOUTH OF LAKE TETANA. SEPTEMBER 1937.

Soon after we started cutting logs for the cabin, having picked a site with a southern exposure, an airplane made a forced and hazardous landing on our small lake. Ice on the wings, together with a blinding snowstorm, forced the young pilot down, and he and his mechanic remained at our camp for four days. Their undisguised astonishment when greeted by Mrs. Fletcher in "this blank country" where only the odd Indian might be expected, was amusing.



MRS. FLETCHER AND CABIN INTERIOR. DECEMBER 1937.

CONDITION OF FOREST IN WHICH WE HAD TO LOCATE DRY FIREWOOD.

Other whites from "outside," traders, game wardens and policemen, had shaken their heads at the thought of a young white lady choosing to live in these wilds —as far as possible from the settlements. The senior writer was told that he had "no right to make any woman give up the proper life to live with the animals." These sentiments were due partly to the extreme isolation of the spot and partly because the local Indians had a bad reputation, somewhat undeserved, we later decided. Any troubles or difficulties which we might encounter we should have to handle ourselves as best we could, for there were no neighbors to call upon and we were cut off from any communication with the outside world for months at a time. The fact that we had no radio and did not want one horrified the white people, and when the Indians saw us trapping mice on a large scale, they spread the report that we were crazy. It took a year and a half for the whites and Indians to realize that we were normal people, quite harmless and not there for some unlawful purpose.

By the first of October, there were many signs of the approaching winter, and it was a fight to get a decent shelter over our heads before the heavy snows came. The autumn gold and burnt orange of the poplars (*Populus tremuloides* and *Populus balsamifera*) no longer lit up the dark blue-green of the spruces (*Picea canadensis*) and the yellow-green of the pines (*Pinus contorta*). Reddish willows and marsh grasses around the lake shore lost their color. The mountains glittered with fresh snow. The cabin went up slowly; peeled pine logs thirty-five feet long were hauled by the pack-horses from the forest nearby, rolled, lifted and fitted into place. The doors and windows were cut out as the walls went up. Moss by the sackful was packed and chinked between the logs, outside and inside; a

OTTER SLIDES ON ONE OF MANY MAPPED LAKES IN DRIFTWOOD VALLEY.

CABIN AND PROVISION TENT. NOVEMBER 1937.

small cellar was dug. We worked long hours and went to bed each night in an exhausted condition. We had, of course, no lumber, and so we cut and split trees down the middle, hewing them into boards for roof and floor, shelves and tables. Eighty-four axe-hewn boards ten feet long and eight inches wide made the cabin floor alone, and, on the flat-hewn roof boards and rafters, went two thousand five-hundred shakes, split laboriously by hand from fir tree blocks and carried from a mile away. The cabin interior measured thirty feet by twenty. But the snow had come long before this was completed. The Indians had been too long away from their homes; one of them lived over two hundred miles away. To be caught by winter without proper preparation in that country was a serious matter, and so they refused to stay after the first real snows came. On October 21st, we waved goodbye to our helpers and the fine little packhorses and were left to the vast silence of the autumn wilderness and to our own resources. On October 31st we moved into the cabin; we had been tent-dwellers long enough. But we missed the nightly raid by the inquisitive and thieving weasels (*Mustela cicognani richardsoni*), the early morning visits from tiny gray-headed chipmunks (*Eutamias minimus caniceps*), the cries of owl, wolf and coyote, and all the strange, hushed night sounds from the deep forest around our seemingly insignificant camp.

We set about furnishing the cabin. In addition to the three glass windows, we put in four others made from a type of mica glass which is obtainable in rolls. Thus, with the two doors, we had ventilation and plenty of light, with views in every direction of the glorious country around us. None of the stuffy one-windowed cabins for us, such as we had seen in other parts of this country, whose owners apparently missed completely the beauties and interests of the wildlife around them. Comfortable beds and arm chairs we made from a framework of small poles, with rope and canvas

REAR VIEW OF CABIN, MEAT CACHE AND SAWHORSE FOR FIREWOOD.

stretched between. Shelves, tables, bookcases and a desk were made from the cases in which our freight had been packed and from hewn pine logs. On our book shelves was a collection of Barrie's Plays, Kipling, Shakespeare, "Winnie-the-Pooh," some poetry, Seton's "Lives of Game Animals," Taverner's "Birds of Canada" and many other reference books on the flora and fauna of British Columbia, a number of "Digests" and a few novels. Bear-skin rugs on the floor, curtains at the windows and the rich brown and yellow satin finish of the peeled log walls made the cabin attractive.

In the meantime we had three or four visitors from the small Indian settlement thirty miles north of us on Bear Lake. These were our closest neighbors, and their trapping lines ran near our vicinity. And these were some of the people about whom we had been warned. They were taller and stronger looking than the Indians we had seen at Babine and Takla Lakes, and seemed to have greater character of their own, due no doubt to their more isolated position and to the fact that they had had less contact with white civilization. The five or six different families at Bear Lake to which they belonged, appeared to be mixtures of the Babine Indians to the southwest, the Sikanees of the country to the northeast and Tahltans from the north. At first we eyed each other with mutual reserve. On the surface they seemed fairly polite and obliging, and we in turn tried to make it clear that we were come as strangers into their country and did not wish to interfere with their lives or cause any trouble. The older ones spoke and understood a very simple type of English. We were, during the ensuing eighteen months, to see a good deal of these Bear Lake Indians, especially the members of the two families who trapped and hunted near us. We went on various trips with them, and on two occasions slept in their crude cabins when

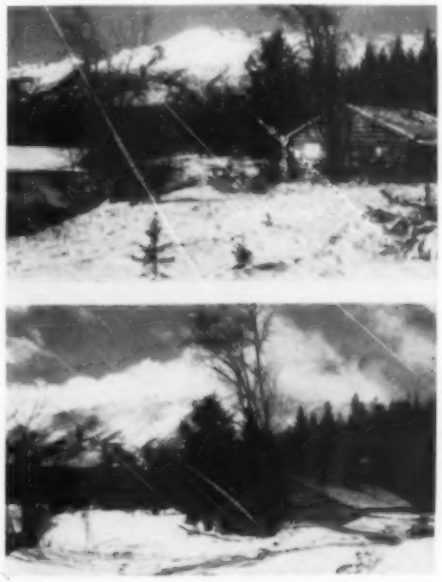
LAKE TETANA SHOWING OPEN WATER NEAR THE CABIN. DECEMBER 1937.

BEAR LAKE CHARLIE AND HIS WIFE SELINA BY THEIR CABIN AT BEAR LAKE. JANUARY 1938.

caught in winter storms. At times they camped near our cabin while they were doing small jobs of work for us. When they made their few journeys past us to visit their trap lines during the hard winter months, we invited them into the cabin for hot tea and biscuits, told them what we could of our work for the Museum and our ideas of conservation. We acquired from them in turn valuable bits of information about the wildlife around us. Our mutual interest in wildlife was always a common meeting ground and source of conversation. When it came to doing any sort of business, they were a peculiar and difficult people to deal with. Most business deals were both angering and exhausting. They made fair guides, were excellent in traveling on the trail and had camping out, under all sorts of conditions, down to a fine art. Their powers of endurance in all weathers, improperly clad and with what we considered a completely inadequate diet, consisting often of tea, bannock and perhaps not even meat, were remarkable. But steady work, such as the average white man knows it, for more than a few days at a time was definitely not their forte.

It is just as absurd to lump all Indians together and imply that they are all alike as to expect all the members of the white race to have characters in common. It was always surprising to us to find how many white people, even those that claimed to know them, had this idea. Although the Indians of this region had certain customs and traits and morals in common, individuals, members even of the same family, differed as to character and personality just as do members of the white race. Those with whom we came in contact, with certain exceptions, had no idea of truth as we understand it, nor could they be relied on. At one time they were friendly and even affectionate, at another for some known or unknown cause, they might be hostile and extremely unpleasant. They were very sensitive and had a remarkably keen intuitive sense closely akin to the wild animals. They all seemed to have a sense of humor and adored practical jokes, and their "tallest" excuses and stories were often accompanied by an obscure twinkle. They had the peculiar Irish trait of being able to make you feel comfortable and elated or quite the reverse.

We had seen and handled natives of other races and color in various parts of the world, so that differences in morals and habits did not disturb us unduly. One of us, who had lived in the Eskimo country for several years, found the Indians of our particular section of British Columbia decidedly inferior to the Eskimos as he had known them. These Indians seemed to us to be in a rather sad state of transition. They appeared to have lost their old strong racial and tribal characters and customs and to have acquired only the poorer characteristics of the white race.



CABIN BY MOONLIGHT AND DAYLIGHT. NOTE DIFFERENCE IN SNOW LEVEL IN LOWER PICTURE, SINCE THE MOONLIT NIGHT TWENTY-EIGHT DAYS BEFORE.

WEASEL AND WEASEL TRACKS.

By Thanksgiving Day the branches of the trees were bent beneath their burdens of snow, and on the level ground there was a mantle three feet deep. Our lake, since it was fed by many springs along the north shore, was only partly frozen over; it was apparently the only lake of its kind in that part of the country. The springs were constant both in quantity and temperature. Temperatures taken on December 26th with the thermometer outside on the cabin wall registering forty-three degrees below zero, Fahrenheit, showed the springs near the cabin to be thirty-eight degrees. Later, during the month of August, when the thermometer showed eighty-eight degrees Fahrenheit in the shade, temperatures were again taken and still read thirty-eight degrees.

Through the early part of the winter, three Barrow's golden-eyes (*Glaucionetta islandica*) occupied the stretch of open water and became quite tame, while two pairs of dippers or water ouzels (*Cinclus mexicanus*) remained until spring. These dippers spent the winter in or around the open spring-fed patches of water in our lake. On a cold winter's afternoon with the temperature around zero, at the end of December, we were startled by a shower of rippling song above our cabin. This song was a cross between a song sparrow, mocking-bird and thrush, and was our first introduction to the dippers. After that they sang to us all winter; the colder the weather the more they seemed to like it. They sang lustily on mornings when it was forty below zero, flying through the air, darting down into the icy water, chasing each other. Often they sang high in the air, dropping down with a shower of notes like a skylark. They were strong, swift flyers, not to mention their remarkable aquatic powers in the water. They could swim under the water or on top, float like a duck, dive off a

log or ice bank like an otter, only to come up dry and merry and sparkling. They spent considerable time feeding on insects under water or along rocks. In December on two occasions we saw a male and female (?) performing the act of coitus. At first it occurred in the water, and a few minutes later on a snow bank, with much twittering and fluttering of wings. These birds used to chase each other over our cabin and in the nearby woods, often in full song. Whether it was one male chasing another male, or a male chasing a female, we could not always be sure. They were quite tame and when we went down the bank to get water would often fly over to us and start feeding a few yards away. Sometimes one dove in a small hole in the ice and swam under the ice for a distance of two or three yards, coming up through another hole nearby. They became scarce by March 10th, and had left our lake by March 19th. But they were seen at open patches of water along the river until June, when they apparently disappeared for their nesting grounds.

Early in December, the tent which we were using as a storehouse behind the cabin, broke down from the weight of snow which fell in a single night. When we dug it out and cleared everything from underneath we discovered some missing specimens which had been stolen by a weasel during the late fall. Two Franklin's grouse skins (*Canachites franklini*) and one made-up white-footed mouse (*Peromyscus maniculatus borealis*) with the cotton-wool bulging from a tear in the throat, were retrieved, and a very annoyed weasel permitted us to shoot him with our cameras. This weasel was one of our most persistent and amusing companions. His eyes, red or green with changing lights, never lost their wicked impish expression. He appeared and disappeared with miraculous rapidity and his lithe, snaky, undulating movements held an absolute fascination. When we had been in the tent in September and October he made himself very free of our quarters, sometimes running over our bodies at night. He was brown above and cream below when we first saw him in late September, but

CANADA JAY AND RED SQUIRREL.

with the first snows in October, his coat became more and more splashed with white, until finally he was creamy white all over, with a black brush on the end of his expressive tail.

Cutting wood for two stoves occupied

a considerable portion of our time. Our helpers in the fall had not stayed long enough to cut a reserve supply. With so much snow on the ground it was necessary to find dead trees in the woods, tap them with the axe—and leap aside on snowshoes, before hundreds of pounds of snow fell from the branches above. If one was slow, or tripped over one's snowshoes, as often happened, the deluge was cold and heavy and one was knocked flat and buried. Logs eight or ten feet long were cut and carried on our shoulders to the cabin, sawed up and split. Blisters and inexperience gave way to hardened hands and decent axe-work after the first few weeks.

We were fairly well supplied with fresh moose (*Alces americana* ssp.) meat at this time. The Indians brought us bits from newly killed moose, and we froze all that we did not need for immediate use as a reserve supply for winter. Moose tongues, hearts, livers and kidneys were especially good. Later in the year one of the Indians showed us how to cook antlers in the velvet, and these were delicious. We killed very few moose ourselves and these only for food, as we were not at all interested in big game hunting and wished to spread the doctrine of conservation as far as possible. We had also occasional meals of mountain goat (*Oreamnos americanus columbiae*) and bear (*Euarctos americanus*) meat, grouse and wild ducks.

By December 10th the temperatures were averaging four to ten below zero, Fahrenheit, each morning and, on rising, our first act was to light the fire in the larger stove. Canada jays (*Perisoreus canadensis canadensis*), with their feathers fluffed out from the cold, demanded attention at our feeding station, and chickadees (*Penthestes gambeli grinnelli* and *Penthestes hudsonicus columbianus*) waited with them. The jays, or "Camp Robbers," were bold and friendly, coming to our outstretched hands for food, when called by a whistle. They learned to know when we were leaving the cabin for a few days trip, carrying packs, and would follow us for half a mile or so, scolding harshly from the tree tops. They also knew when we were returning, for on many occasions they met us when we were a mile from the cabin and flew around us with many a coo and trill, all the way back to the cabin.

CANADA JAY.

The long quiet winter evenings in the warm cabin with the snow piled high outside the windows were a never-ending joy. By mid-December the sun set behind the mountains at 1:30 P.M., and it grew dark at 3:30 and was not light again until 9:00 A.M. By 4:00 P.M. we settled down to read and work and play games with the knowledge that nothing and no one would disturb us. Each evening was a perfect balm to the nerves and we were never bored.

We were beginning to feel acquainted with the countryside. Endless numbers of small hills and ridges rose gradually to mountain ranges on the east, and more abruptly to the steep Driftwood Mountains on the west. There were hundreds of lakes, large and small, in every direction. Willow swamps, interspersed with small grassy meadows, beloved of moose, and sphagnum bogs alternated with the heavy stretches of forest. In the swampy lowlands these forests consisted of heavy black and white spruce (*Picea mariana* and *Picea canadensis*),

and some balsam (*Abies lasiocarpa*). On the moist slopes of hills and mountains, it was often composed of almost solid stands of magnificent balsams over one hundred twenty-five feet in height, with impenetrable undergrowth of Devil's-club (*Fatsia horrida*) and small shrubs. The dry ridges and old burnt-over places were covered with jack-pine (*Pinus contorta*) and poplars (*Populus tremuloides*). We climbed all the small hills around us for views of the untouched wilderness which was always different with changing lights, now utterly silent in the depths of winter. A cry or shot from one of us was instantly muffled by the snow-laden trees. Sometimes the snow came down for days, as though a giant flour-sifter had been turned on. During the winter there was seldom any wind and after each fresh snowfall we were able to flounder about on our snowshoes only a few miles a day. Animal signs were scarce. The animals could not get about even as readily as we could. We found that it was absurdly easy to become completely lost in this country. Blazes on trees as trail markers, which had been made shoulder height during the autumn, were at or below the snow level; the snow-laden trees looked all alike to us, while the mountains nearby were not visible from the floor of the forest. Once, on a bright sunny day, one of us discovered, after following a marten track (*Martes americana actuosa*) for some hours, and noting where it had nearly succeeded in catching a grouse or had stalked a red squirrel (*Sciurus hudsonicus columbiensis*), that he was in a strange part of the woods. Actually he was within two hundred seventy-five yards of the cabin, but it took two hours of backtracking on the snowshoe trail to find this out.

On one very snowy morning, at dawn, we saw from our windows a moose on the lake where the ice was firm at the southern end. A day later, when we got up to light the morning fires we saw something surprising. In the open water below the cabin a Barrow's golden-eye paddled aloofly and indignantly away from a snow-white varying hare (*Lepus americanus pallidus*), which was then forty feet from the shore and going through the water with tremendous thrusts from its large hind feet. After a few more strokes it hesitated, turned and swam back, then was lost from sight behind the snow bank. On investigating its tracks in the snow we found that the hare must have entered the water deliberately, for there were no signs of other pursuing tracks. It had spent a moment on the shore after emerging, left a few pellets, and then leisurely headed back toward the woods where its trail was lost among dozens of other hare tracks and runways. We could not see any reason for this morning bath, and wondered how the animal dried its fur and survived—if it did.

At 7:00 A.M. on Christmas Day our maximum and minimum thermometer, which registered fifty-two degrees below zero, Fahrenheit, was jammed by the mercury being forced around the indicator, which was wedged into the upper bulb, where it remained. The same day, what we took to be an otter, left a cleaned and decapitated Dolly Varden trout (*Salvelinus malma*) weighing two and one-quarter pounds, on the edge of the snow-covered lake ice near the cabin. Our mouse traps were producing few specimens, and so on New Year's Day, 1938, we started on an exploration trip toward Bear Lake. We did not know the correct trail route, and the summer trail was buried under the snow, the blazes hidden. But we had plenty of time, food for a week in our packs, an axe and some bedding, and the inevitable cameras, binoculars, skinning kits and rifles, slung around our necks. Our snowshoes were long and narrow, upcurved at the toes, and made a good trail by which we could (we hoped) find our way home again—providing no more snow fell while we were away.

We found moose tracks plentiful and

saw a number of Franklin's grouse; along the shores of some of the frozen lakes were fox (*Vulpes fulva abietorum*) and mink tracks (*Mustela vison energumenos*), and on one lake there were signs of three otters (*Lutra canadensis evexa*) which had traveled over the surface, running a few paces and then folding their legs to their bellies and sliding on the snow for a distance of ten to fourteen feet at each slide. Once or twice we saw fisher tracks (*Martes pennanti columbiana*) in the thick and tangled forest. This country was part of Indian Sapolio's hunting grounds, and we found later that here at any rate was one Indian who apparently made an attempt to conserve his fur bearers, for he kept a count of the numbers of animals on his line, and the years in which he trapped them, allowing definite periods to elapse when the took no skins of a certain species. We can not say the same for the majority of the people in that region.

At nights we "siwashed," or slept under a large tree with a fire made of four or five big logs before us. Below the trees the snow was less deep and our fire, after the first hour or so melted the snow until the burning logs were level, or below, our bed of spruce branches and "ground-hog" robes, made by the Bear Lake Indians from the local hoary marmot (*Marmota caligata oxytona*). Sometimes it was bitterly cold; the great fire melted the snow around us and made our moose-skin moccasins wet; if we moved away from the blazing logs we froze. Many of the nights were wonderful. On black ones, the glow of the fire lit up the big spruces and shut us in a room of red light and shadows. When it was moonlight, the mountains and forests around us were light as day in their glistening blanket of snow. But when our food supply was low and we were hungry and dead tired after a long day, the marvelous beauty around us often seemed utterly impersonal and unreal.

During this short trip we made several discoveries; first, that pack-dogs, used universally in that country by the Indians for carrying supplies, would be a blessing to tired shoulders and aching backs. Second, that every moose in the country was heading southward and not resting on the way. From the Indians we later learned that this year there was a general southerly movement by the moose in all parts of the district, and the older men told us that this indicated a heavy snowfall in the near future.

There were no signs of wolves (*Canis* sp.) at this time, though many were to be seen later, and when the snow was really deep, eight feet on the level, those few moose still in our vicinity had a sorry time of it. We noted that in order to travel across open places where the snow was deepest, they bent their forelegs at the knees and used their lower legs as snow-shoes. This packed the snow somewhat, and enabled them to keep their bodies near the surface.

Note: Annotated lists of plants and animals collected will be published elsewhere after further study and when identifications are completed. All illustrations have been made by the authors.

GEOGRAPHIC INFLUENCES ON ALAND'S WINDJAMMERS

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HEAD OF THE DEPARTMENT OF GEOGRAPHY, MASSACHUSETTS STATE TEACHERS COLLEGE

THE romantic windjammers of the Åland Islands, which just now are one of the chief objects of Russia's attack on Finland, have probably been a greater influence in advertising this Baltic archipelago (Fig. 1) than any other phase of its geography. Each year newspapers, magazines and books carry columns about the annual grain race from Australia to northwest Europe. Each year the Ålands are pictured as the home of the last of the great sailing fleets. Each year Captain Gustaf Erickson, the owner of the Åland Islands' fleet, comprising the most of the thirty or more large windjammers of the world, gives a few interviews to tourists visiting Mariehamn, the capital of the Ålands (Fig. 2).

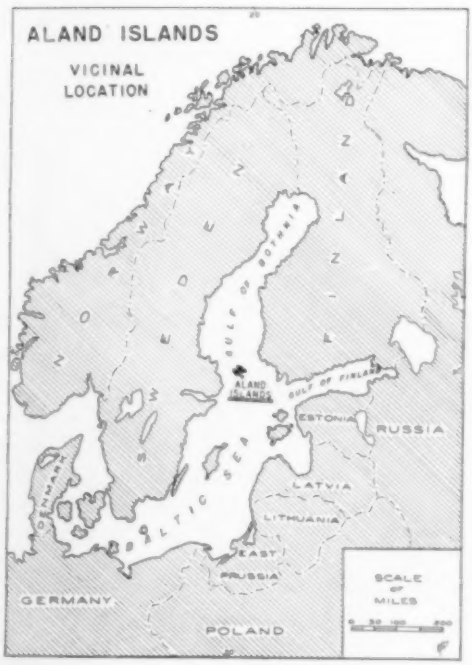

FIG. 1. THE ÅLAND ISLANDS

THE ÅLANDS COMPRISE OVER SIX THOUSAND ISLANDS WITH AN AREA OF APPROXIMATELY FIVE HUNDRED AND FIFTY SQUARE MILES, BUT THE TWENTY-FIVE THOUSAND PEOPLE, WHO LIVE MAINLY BY FARMING AND FISHING, OCCUPY ONLY EIGHTY OF THE ISLES. THE ARCHIPELAGO BELONGS TO FINLAND AND FORMS A DIVIDING ZONE BETWEEN THE BALTIC SEA AND THE GULF OF BOTHNIA, AND A BUFFER BETWEEN THE SCANDINAVIAN PENINSULA AND THE EUROPEAN MAINLAND.

It was the author's good fortune to secure such an interview near the close of a round-the-world trip in 1936. As a geographer I was interested to learn whether geography can account for the last stand of the barks, barkentines and full riggers in the land of six thousand islands. "Is there something peculiar about the climate, the location or the land forms of Åland, the largest isle of the Åland Islands, which attracted the owner of this fleet of sailing vessels?" I asked. Mr. Erickson replied in the negative, and indicated that any one of a number of ports in northwest Europe could qualify as the home of the sailboats just as well as Mariehamn. Stockholm, Oslo, Bergen or Copenhagen would serve the purpose equally well. The human factor, too often little stressed in geography, holds the answer to this question. Man is given a choice within a general area as to where he may carry on this industry, just as he is usually given a choice within certain limits in determining the location of many other world industries. Captain Erickson chose Mariehamn (Fig. 3) as the home port for his sailing fleet largely because his home is in the Åland Islands and he loves the strategically located Baltic archipelago. Moreover, his choice can be defended from a geographic standpoint. The capital of the Ålands pos-

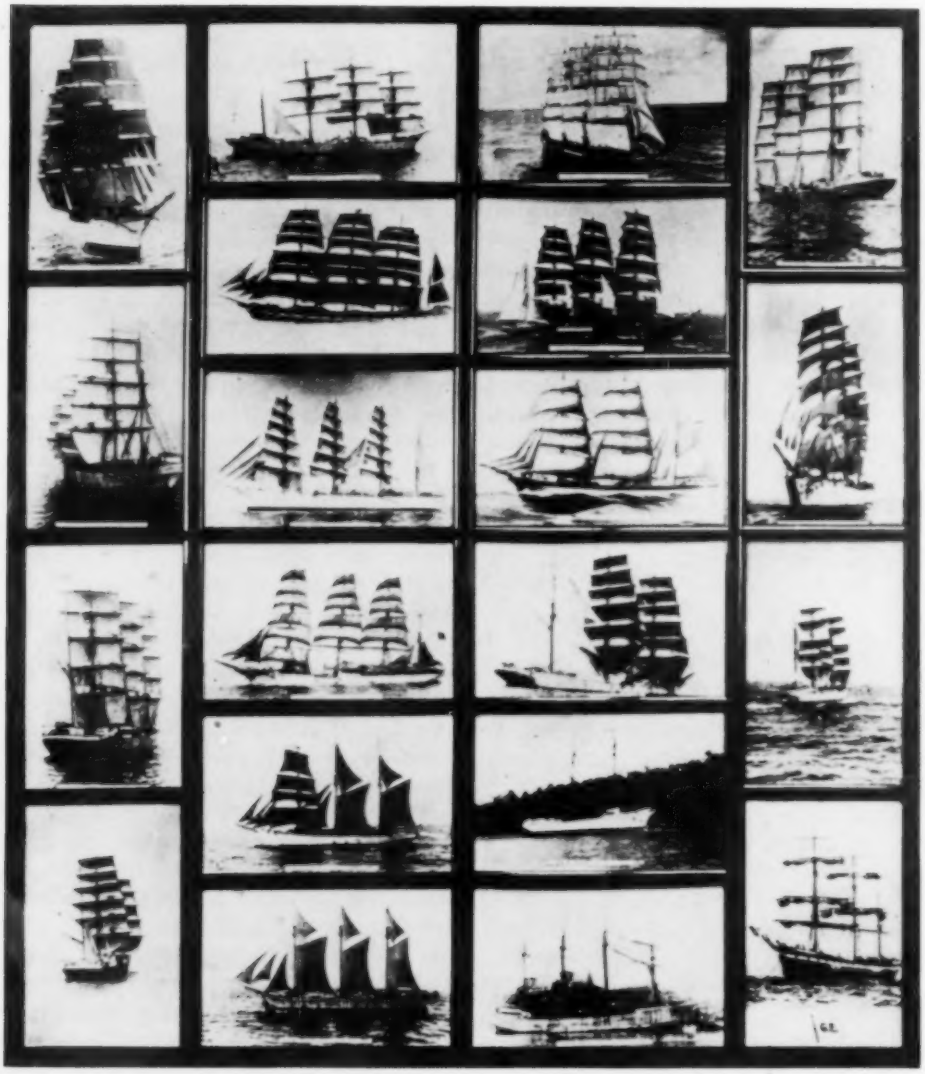

FIG. 2. TWENTY OF CAPTAIN ERICKSON'S SAILING SHIPS

sesses a good harbor which is not too far away from the dense populations of northwest Europe, who afford the market for the wheat cargo of the windjammers.

Although the physical geography of the islands played a minor rôle in the final choice of a home for the sailing fleet, physical factors are extremely important in the choice of the routes followed and other phases of the sailing ship grain trade. One of the most important influences is climate. Sailing from Mariehamn to Australia involves a passage through all of the world's major wind belts except the belts of the polar easterlies. The westerlies, subtropical calms, trade winds and equatorial calms are all encountered on the journey to and from Australia (Fig. 4).

To illustrate the wind conditions encountered by the sailboats on their voy-

age for wheat from Mariehamn to Port Lincoln, Australia, the writer has prepared a map of the world wind belts and on it indicated the route usually followed by the windjammers. Of necessity the wind directions shown are highly generalized and the polar easterlies as well as the Asian monsoons are entirely omitted. Moreover, the trades and westerlies are shown blowing from their most dominant directions, whereas any student of climatology knows that on many occasions their paths are far different from text-book illustrations. In spite of these omissions, the author feels that the map may be useful as a practical teaching device for students beginning the study of world wind belts, and the preparation of the map was largely motivated by this aim.

Invariably the fleet makes the trip out from northwest Europe by rounding the Cape of Good Hope at the southern tip of Africa and sailing eastward to Australia with the aid of the westerlies. On the return, with full cargo, the start of the 14,000-mile journey is likewise encouraged by these winds, for the ship's prow continues eastward around the Horn, at the poleward point of South America, in an ocean area which demands the best of the sailor's skill while passing through this home of the "Roaring Forties." Not always are the westerlies an advantage to the windjammers, for according to Captain Erickson, they may cause the greatest delay encountered on the journey. It is when the ships leave Mariehamn in August and September that the greatest trouble may occur. During this period, southwest winds usually prevail, and the captain stated that on one voyage his ship took twenty-nine days to travel from Mariehamn to Copenhagen, a distance which can easily be made in two days with favorable winds. This occurrence is unusual, of course, but it is well to remember that the westerlies may be as fickle in direction and consistency as other winds with more notorious records. While the prevailing winds and storm movements are from the west the air may move from every point of the compass, a fact well illustrated by wind frequency in the Scilly Islands lying in this wind belt just to the south of England (Fig. 5).

Once out of the belt of the westerlies the ship, if it is fortunate, may find north winds around the Azores high off the southwest coast of Spain (Fig. 6). With their aid and that of the south-flowing Canaries Current, the windjammer can easily sail into the belt of the northeast trades, where strong consistent winds blowing day after day against giant sails will push the Australia-bound boat rapidly equatorward (Fig. 7).

Approaching the equator, the sailing ship usually crosses the dreaded equatorial calm belt between 25 and 28 degrees West Longitude, a little west of a north-south line directly south of the Cape Verde Islands. Here the doldrum belt reaches its narrowest extent, and if the gods of luck are smiling, the craft may encounter no calms at all. Such was the good fortune of the Erickson boat *Lawhill*, which in 1921 found neither horse-latitudes, nor doldrum conditions from Biscay to the Line. Instead, the freighter sailed swiftly across the equator on August 31, pushed forward by the northeast trades which graciously extended themselves beyond their usual boundaries into the belt of the southeast trades (Fig. 7).

While these winds lend less assistance to boats journeying to the Antipodes than those blowing from the northeast, skilful sailing may get the boat through their territory in two weeks' time or even in a shorter period. The southeast trade winds may be lost near the small isle of Trinidad, 20° 20′ South–29° 40′ West, where counter-clockwise northwest winds around the subtropical high enable ships to get southward and eastward (Fig. 8), and by the time Tristan de Cunha, 35° 30′ South–12° 15′ West, is reached they en-

FIG. 3. THE HARBOR AND PART OF THE TOWN OF MARIEHAMN

THE ÅLANDS' CAPITAL, WHICH IS LOCATED ON THE SOUTH SHORE OF ÅLAND ISLAND, THE LARGEST OF THE GROUP, HAS A POPULATION OF ABOUT 1,000 PEOPLE AND IS BECOMING A POPULAR SUMMER TOURIST TOWN.

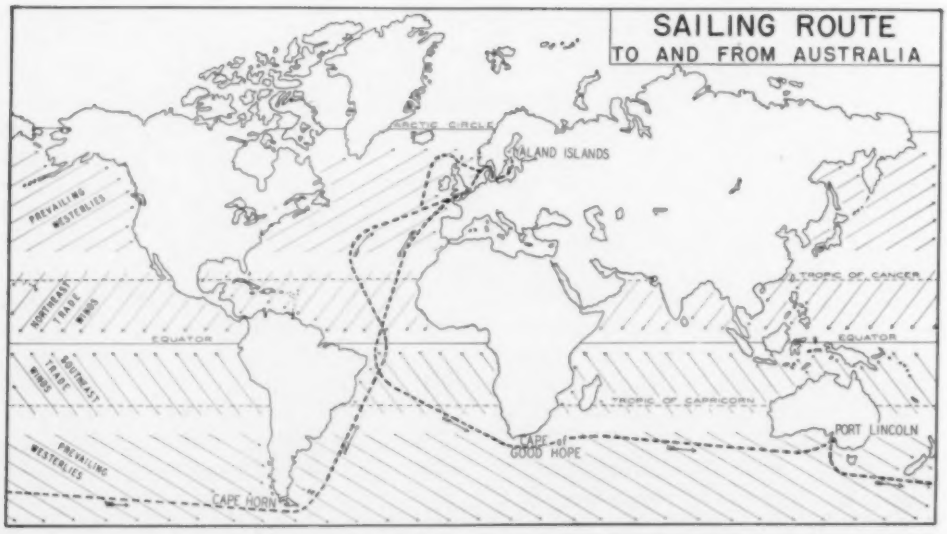

FIG. 4. SAILING ROUTE TO AND FROM AUSTRALIA

SHIPS FOLLOW THIS GENERALIZED ROUTE MOST OF THE TIME, GOING OUT BY WAY OF GOOD HOPE AND COMING BACK AROUND THE HORN. WIND BELTS AND WIND DIRECTIONS ARE OF NECESSITY DRAWN HIGHLY DIAGRAMMATIC, AND THE POLAR EASTERLIES AS WELL AS THE ASIAN MONSOONS ARE ENTIRELY OMITTED.

counter the westerlies which, a little farther south, sweep eastward whatever comes into their path. Once into this desired path, the windjammers find easy sailing for Australia, and after loading cargo these same strong winds propel them well on their way homeward. A. J. Villiers, in his interesting narrative, "Falmouth for Orders," tells of the *Herzogin Cecilie*, an Erickson boat, making the 5,000-mile stretch from New Zealand to the Horn in 17 days—an average speed of approximately twelve and one-half miles an hour, or three hundred miles a day (Fig. 7).

In contrast, the trip from the westerly belt through that of the horse-latitudes may be as slow and tedious as beating head winds from Mariehamn to Copenhagen. Turning again to Villiers' book, Captain Erickson read a passage telling of the trials encountered by the *Herzogin Cecilie* after reaching Cape Horn from New Zealand in 17 days. For 27 days she slowly made her way from the tip of South America to a point at 21 degrees South Latitude into the southeast trade wind belt. On this homeward stretch the counter-clockwise northwest winds around the subtropical high, which usually help on the way out to Australia, persistently opposed the ship's progress. Her average speed from the westerly belt through the horse-latitudes to the trades of approximately one hundred miles a day was less than one third the rate made with the help of the westerlies.

The southeast trades may give the home-bound ship speed nearly as swift as that achieved in latitudes below the Horn, especially if the wind has a stronger southerly than easterly component. Passing from 21 degrees South Latitude to 4 degrees South Latitude the *Herzogin Cecilie* made approximately 1,200 miles in five days—not quite as fast as the jaunt to the Horn from New Zealand, but still fast sailing for a windjammer.

The passage through the latitudes of

FIG. 5. SCILLY ISLANDS

MOST MARINE STATIONS IN THE BELT OF THE SOUTHWESTERLIES SHOW A HIGHER PERCENTAGE OF WESTERLY WINDS. HOWEVER, THIS STATION WAS CHOSEN TO EMPHASIZE THE FACT THAT WINDS IN THIS BELT MAY BLOW FROM EVERY POINT OF THE COMPASS. DATA FROM "CLIMATE," P. 103, BY W. G. KENDREW.

the equatorial calm belt (Fig. 7) is seldom as easy as that of the outgoing *Lawhill* mentioned some paragraphs above. In contrast, the *Herzogin Cecilie* found conditions about as Columbus found them when he crossed the Line on his memorable third voyage to the Americas. Just as the great navigator waited day after day for a favorable breeze, so did the crew of the *Herzogin Cecilie* as they cursed the calms, light winds and rain, the three demons which haunt sailing

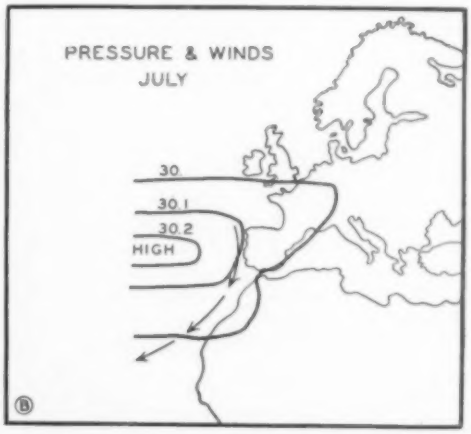

FIG. 6. AROUND THE AZORES HIGH

CLOCKWISE NORTH AND NORTHEAST WINDS AROUND THE AZORES HIGH MAY AID THE WINDJAMMER ON THE OUTGOING VOYAGE.

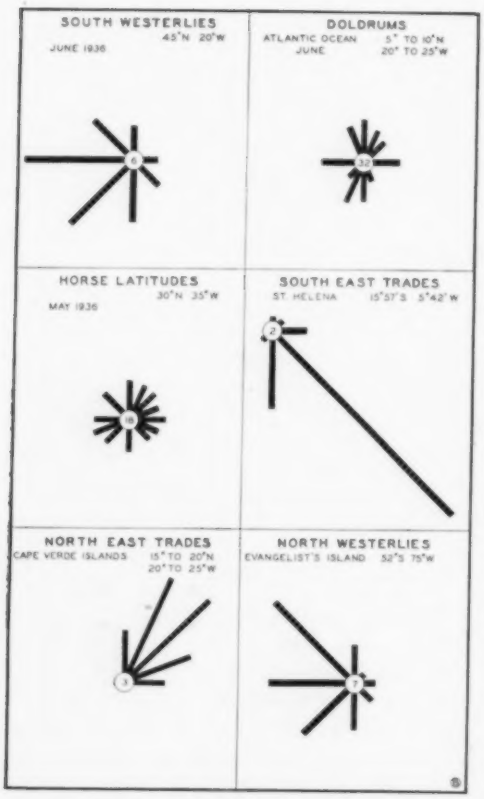

FIG. 7. WIND ROSES

TEMPERATE, SUBTROPICAL AND TROPICAL WIND BELT. THE ABOVE ROSES SHOW DIRECTION PERCENTAGES FOR TYPICAL LOCATIONS IN THE MAJOR WIND BELTS THROUGH WHICH THE WINDJAMMERS PASS. NO ROSES ARE GIVEN FOR THE HORSE-LATITUDES AND DOLDRUMS OF THE SOUTHERN HEMISPHERE, BUT THEIR WIND CONDITIONS ARE SIMILAR TO THOSE OF THE CORRESPONDING BELTS OF THE NORTHERN HEMISPHERE. DATA FOR ALL WIND ROSES, WITH THE EXCEPTION OF THAT FOR EVANGELIST'S ISLAND AND ST. HELENA, WERE OBTAINED FROM CHARTS FURNISHED BY THE U. S. HYDROGRAPHIC OFFICE, WASHINGTON, D. C. THE STATISTICS FOR ST. HELENA WERE TAKEN FROM "CLIMATE," P. 90, BY W. G. KENDREW, AND THOSE FOR EVANGELIST'S ISLAND WERE OBTAINED FROM "CLIMATES OF THE CONTINENTS," P. 317, BY W. G. KENDREW.

ships as they attempt to sail across the earth's bulging waist line.

Windjammer captains encountering the northeast trades after a siege in the doldrums may or may not be much relieved. If the winds come directly from the northeast, the ship will find it difficult opposing these helpmates of the outgoing voyage. If the trades are more easterly than northerly, the problem will be less troublesome. Once out of the tropics, the calms of the horse-latitudes may encourage cursing as loud and vociferous as that expressed in the doldrums (Fig. 7). But when this barrier is passed, the ship enters the westerlies of the Northern Hemisphere and with their southwesterly urge blowing on its full-spread sails, the windjammer can quickly carry its cargo of wheat to the final destination (Fig. 7).

The preceding paragraphs illustrate how geographic factors influence the whole journey of the windjammers. Each wind belt contributes its favor or withholds it, depending on the time of year the voyage is made, the route the ship takes, whether with or against the prevailing wind, the selection of a course through the wide or narrow section of any specific wind belt and many other geographic conditions. If the gods of wind and sea smile with favor, the windjammer may make the journey swiftly and with ease, but if wind and wave are unpropitious the voyage may take two or even three times as long. The swiftest passage ever made from Australia to the British Isles by an Erickson boat was completed in approximately 63 days, but most return jaunts consume at least 80 days. The *Herzogin Cecilie*, winner of the 1936 derby, took 86 days before being wrecked on the Devon coast at the end of her run.

Not only does geography influence the choice of routes and the sailing time of the windjammers, but it also shows itself in the varied nationality of the members of each vessel's crew of twenty to thirty men. As an example, the *Passat*, which won the grain race in a recent year, carried what might be called an international crew. Sailors from Russia, Sweden, Finland, Belgium, France, Germany, England and the United States were listed on its payroll. The wind-

jammer is not troubled with the problem of "shanghaiing" a crew, as were many of the clipper ships of the 1850's. On the contrary, officers have to keep a constant watch in port to keep off stowaways. Moreover, most of the best navigation schools require a year of experience on square-rigged ships before admission, so boys looking to their mate's papers are eager to sign for five dollars a month and their keep; some actually pay for a chance to sign, with the opportunity it offers for a sail around "Cape Stiff" in a real square-rigger.

The low cost of hiring a crew is but one of the economies practised by Captain Erickson in operating his fleet of sailing ships. The initial cost of each vessel is also ridiculously low. After the war, when the Captain began to accumulate his windjammers, the shipping industry was depressed lower than the average wind velocity in the doldrum belt. Most shipping companies cut down their holdings radically, especially holdings of sailing ships, and made drastic price concessions to those optimists who believed there were profits still to be made from this class of ocean carriers. Erickson was one of those optimists. His purchase of the *Herzogin Cecilie* may be cited as an example of Åland shrewdness. He paid $20,000 for this beautiful German ship as she lay in a French port, and within two years received more than the purchase price in freights on Australian wheat and Chilean nitrate.

Recently the captain started a service from England to Åland which may add revenue to that procured from hauling Australian wheat. After the windjammers unload their grain in Britain they are ready for the last leg of their journey to the home port of Mariehamn, where they may be repaired and refitted for the next journey to the Antipodes in the autumn. In order to pay some of the expense of the England-to-Mariehamn journey, their efficient owner conceived the idea of offering passage for the Ålands to tourists. The project has been received with considerable success, and each year many people enrich their vacation to the Baltic by traveling there on one of the competitors in the great Australian grain derby (Fig. 9).

The advertisements for this service contain some unique information. The vessels can accommodate from eight to a score or more of passengers, who must be able-bodied in order to obtain a ticket. Tourists are signed as members of the crew, for strictly speaking the ships are not allowed to take passengers. Nevertheless, no duties coincident with sailing the ship are requested from the travelers. No ship's doctor, special steward or stewardess is carried on board, a situation which suggests the stipulation that all would-be tourists must be in good physical condition. Another interesting feature of the contract between passenger and company is that the passenger takes all risks of the voyage, signing away any rights for damages from the ship owner in event of accident.

Mr. Erickson carries no insurance on his vessels, for the expensive rates would

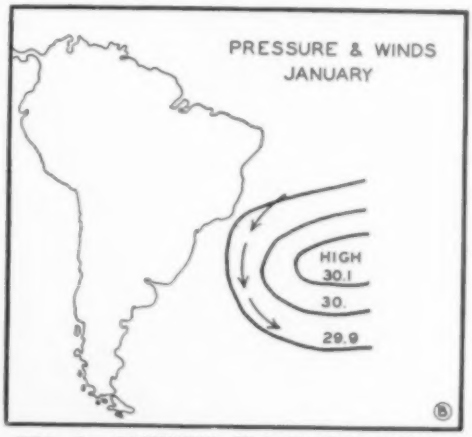

FIG. 8. COUNTER-CLOCKWISE WINDS AROUND THE SUBTROPICAL HIGH, SOUTHERN HEMISPHERE. COUNTER-CLOCKWISE NORTH AND NORTHWEST WINDS AROUND THE SUBTROPICAL HIGH PRESSURE AREA BETWEEN SOUTH AMERICA AND AFRICA MAY AID THE WINDJAMMERS ON THEIR OUTGOING VOYAGE BUT MAY CAUSE DELAY ON THE RETURN TRIP.

FIG. 9. "L'AVENIR"
THIS BEAUTIFUL MEMBER OF THE SAILING FLEET IS PICTURED AT THE HOME PORT AFTER THE FINISH OF THE 1936 GRAIN RACE.

call for a sum almost as high as the initial cost of the ship. Hence he chooses to run his own risks. Out of twenty or more vessels making the annual grain race, there is an average loss of one a year.

Some purchasers of wheat are encouraged to charter the Erickson boats because of the long storage offered by the period of approximately three months required for the wheat cargo to make the voyage from Australia to northwest Europe. Moreover, the grain may arrive on the market in May or June, which is later than many of the steam-driven cargoes arrive and still prior to the time of maturity for most northern hemisphere grain. Sometimes the May or June arrival gives a definite price advantage.

With but little money needed for hiring a crew, with other operating costs at a minimum and with an exceedingly low investment, Captain Erickson can offer a delivery rate for wheat cargo at least two and one-half shillings a ton less than that offered by steamships. Moreover, the Erickson ships get considerable cargo by calling at out-of-the-way Australian ports, where steamers offer little competition. From some of these ports no railroads reach the interior, no elevators offer storage for the grain, and the cereal is hauled in sacks directly from the farms to the windjammer. It is only because of concessions such as lower freight rates and calls "off the beaten path" that Erickson is able to keep his vessels operating. How long they will be able to continue no one knows. He says, "possibly twenty years." At any rate, wheat is the only commodity which offers much cargo, and if no other commodity can be found to take its place, whenever Australia goes entirely "steamship"—most Australian grain is shipped that way now—the Ålands' windjammers may be dismantled for scrap.

SPECTROCHEMICAL ANALYSIS

By Dr. A. E. RUEHLE

BELL TELEPHONE LABORATORIES

WHEN a substance is heated to incandescence or excited electrically, each of the elements present emits light of wavelengths which are characteristic of that element. By analyzing the light emitted with a spectrograph, the nature and amount of the elements present can be found. Several thousand chemical determinations are made each year at the Laboratories by this method. It is an extremely sensitive method and will detect minute quantities of matter.

A sample of the material to be analyzed is heated to incandescence in the cup-shaped electrode of an electric arc whose light then takes on the character of the elements in the unknown substance. This light is split by a quartz prism into a spectrum and recorded as lines on a photographic plate. The elements present in the sample are identified by comparing the positions of these lines with those of the known lines of the different elements. With a spectrograph of good dispersion, any metallic or metalloid element can be detected in a mixture.[1] Non-metals require special methods of excitation and the intensity of their spectra varies greatly with the nature of the mixture in which the element is found.

The intensity of a spectral line depends on many factors besides the abundance of the element in the source, but the experienced spectroscopist can make a fairly good estimate of the amount of

[1] *Bell Laboratories Record*, May, 1928, p. 289.

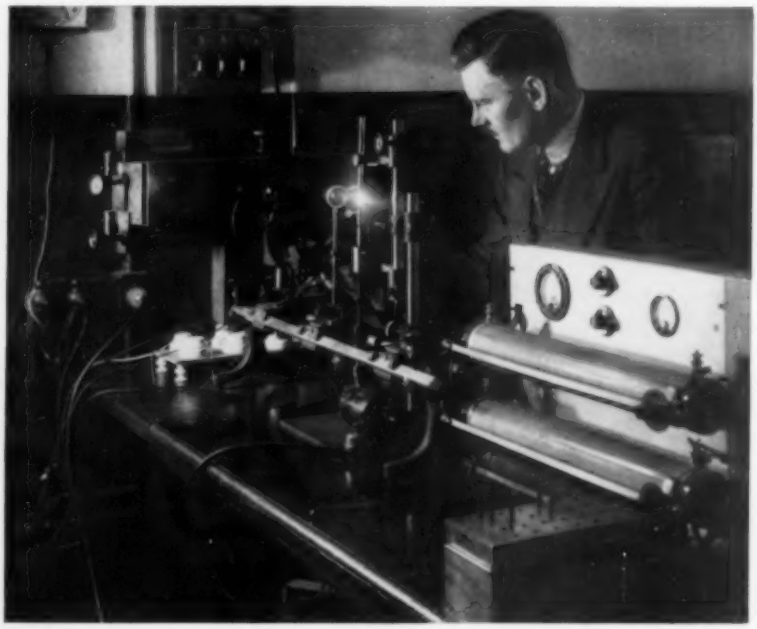

FIG. 1. PHOTOGRAPHING AN ARC SPECTRUM.

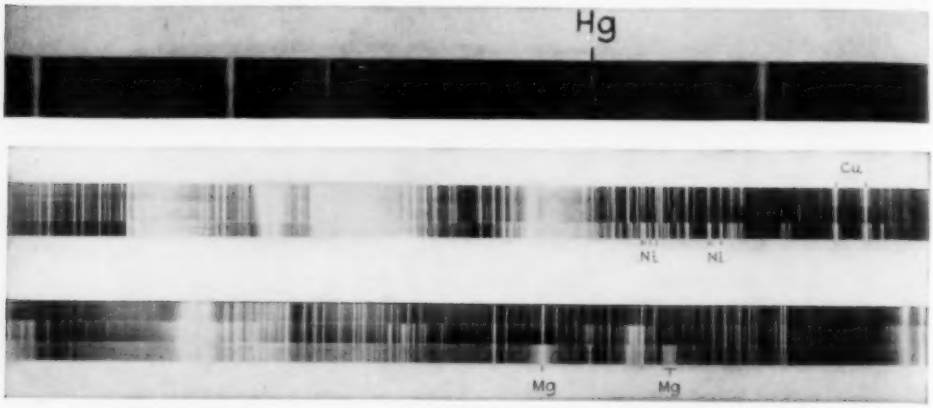

FIG. 2. (ABOVE) DETECTION OF MERCURY AT THE POINT OF FAILURE OF ZINC SUPPORTS FOR AERIAL CABLES. (BELOW) DETECTION OF MINOR COMPONENTS, MAGNESIUM, NICKEL AND COPPER, IN ALUMINUM ALLOYS.

each element present. This serves as a convenient guide for a later quantitative determination either by spectrochemical or ordinary methods.

The identification of contact materials is an excellent example of the technique of estimation. It permits finding of what materials a contact is made without removing the instrument from its mounting, without impairing the contact for further use, and without more than momentarily interrupting its service. The surface of the contact is rubbed with a small piece of pure abrasive paper, the paper is burned in a carbon arc and the resulting spectrum photographed. From the lines in this spectrum, which do not appear in that of the abrasive paper alone, the elements which compose the contact can be identified and their proportions estimated (Fig. 3).

The most direct method of quantitative analysis is to compare the spectrum of the sample with the spectra of prepared standards taken under the same conditions and on the same photographic plate (Fig. 4). It is generally difficult to prepare a series of homogeneous solid standards for this purpose. A more practical method is to put the sample in solution and to compare it with standard solutions of known concentration. Measured portions of each solution, dried on graphite electrodes, then serve as the test pieces for the analysis. This general method can be applied directly to a large number of cases without appreciable modification. Difficulties arise only when one or more

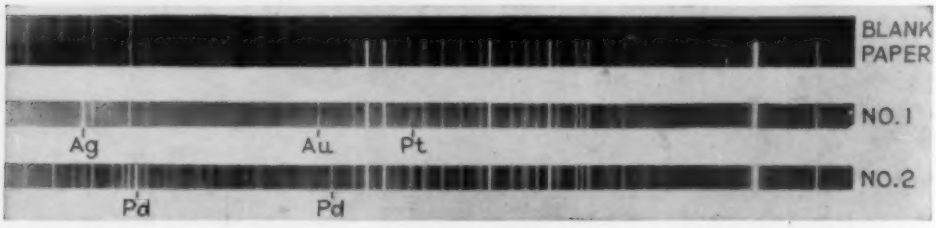

FIG. 3. THE ELEMENTS IN CONTACT ALLOYS CAN BE IDENTIFIED WITHOUT DESTROYING THE CONTACT.

components of the sample in question are not readily held in a reasonably concentrated solution. By this method the amount of an element present in the sample can be determined to within about 10 per cent.

Much progress has been made in devising methods of avoiding the use of standard spectra on every plate for routine work. For example, a curve which shows the difference in density of an impurity line and that of a line of some invariant component of a mixture, as the amount of impurity changes, can be used as a reference standard to determine the amount of the impurity in an unknown mixture. Changes within reasonable limits in excitation conditions or photographic technique will change the density of both the impurity line and the reference line in the same direction and to the same degree. This is called the internal standard method. It gives the most precise results yet attained in spectrochemical analysis, but to reach this precision it is necessary to calibrate the response of each photographic plate for different intensities of the spectral lines. This is conveniently done by a step-sector as shown in Fig. 5. By rotating the sector in front of the slit, spectra are obtained with steps of different density. Plotting from densitometer readings the density of each step of a line against the logarithm of the exposure, *i.e.*, the logarithm of the angular apertures of the sector, gives a curve which shows how the density of a line changes with intensity for that plate. Since the shape of the curve varies from plate to plate, the difference in density of two lines will not be comparable unless corrected for this variation. By taking these factors into account the precision of quantitative determinations has been more than doubled.

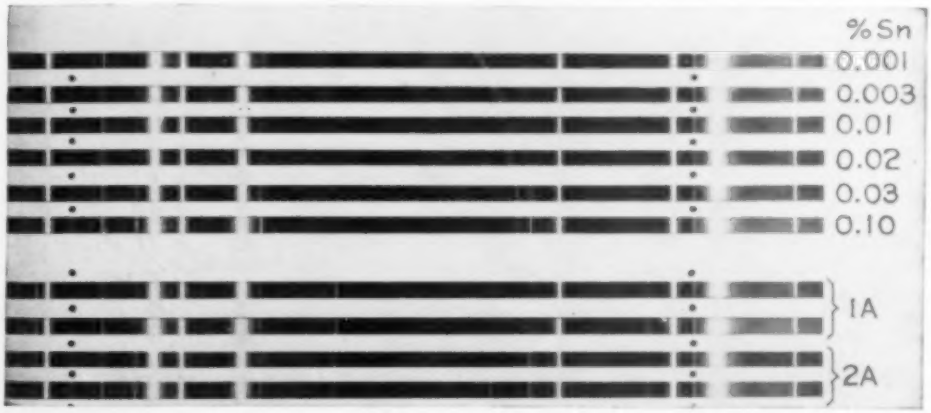

FIG. 4. QUANTITATIVE DETERMINATION OF TIN IN CABLE SHEATH.

Many times the spectrochemical method can be applied as a probe when two presumably identical materials show unexpected differences in behavior. Nominally pure materials are never really pure and may introduce unsuspected impurities which vary with different lots of materials. The spectrograph shows differences in composition of the final product and thus often indicates the beneficial or detrimental effect of impurities.

Most spectroscopic analyses are made with emission spectra, but absorption spectra can also be used. If light of all

FIG. 5. STEP-SECTOR WHICH IS ROTATED IN FRONT OF THE SPECTROGRAPH SLIT DURING AN EXPOSURE TO DETERMINE THE EXPOSURE-DENSITY CHARACTERISTIC OF THE PHOTOGRAPHIC PLATE FOR LIGHT OF DIFFERENT WAVE-LENGTHS.

FIG. 6. TYPICAL ABSORPTION SPECTRA. EXPOSURES ARE MADE IN PAIRS: ONE THROUGH THE ABSORPTION MEDIUM AND THE OTHER THROUGH A CALIBRATED DIAPHRAGM. BY MAKING A SERIES OF PAIRS WITH DIFFERENT DIAPHRAGM OPENINGS LINES CAN BE MATCHED IN DENSITY AS INDICATED BY THE DOTS.

wave-lengths passes through a solution, the amount absorbed will not be the same for all the different wave-lengths; the spectrum of the emergent light will contain bands of different intensities. The amount of selective absorption may be used as a measure of the concentration of the dissolved substance (Fig. 6). Advantage is taken of this phenomenon in the colorimeter and more specifically in the spectrophotometer, which employ visual matching to determine the amount of absorption. In a similar manner the spectrograph and a suitable photometer, used to measure the densities of the absorption spectra plates, find application for this type of analysis. Either visible or ultra-violet absorption bands can be used.

Another method of analyzing certain types of organic compounds is to measure the intensity of the fluorescent bands

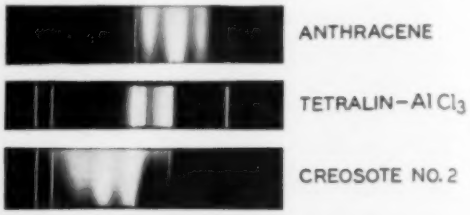

FIG. 7. FLUORESCENCE SPECTRA EXCITED BY MERCURY LINES.

characteristic of the compound in question (Fig. 7). In this case ultra-violet light is used to excite the fluorescent bands and the intensity of the bands is compared with that of the same bands in standard solutions of the same compound.

It is only in comparatively recent years that the spectrograph has come into widespread use for quantitative chemical analysis, but it has already proved itself a powerful tool, particularly for quick estimates of composition and where only minute quantities of material are available.

METHODS OF USING NATURAL GAS

Dr. G. ROSS ROBERTSON

ASSOCIATE PROFESSOR OF CHEMISTRY, THE UNIVERSITY OF CALIFORNIA, LOS ANGELES

NATURAL gas, used sporadically in various oil districts, and usually wasted prodigiously, was not taken seriously as a major fuel in America until long after the World War. The huge oil developments of recent years, however, in Texas, Oklahoma and California have now really attracted attention to this beautiful clean fuel. While we were sitting up and taking notice, the regrettable practice of wasting gas continued and grew apace. The writer recalls the sight only nine years ago of one field station in California blowing off through a hill-top vent pipe eighty million cubic feet of natural gas daily. This waste gas was of just twice the heat value of the fuel which a New York or Massachusetts citizen buys at fifty cents to one dollar per *thousand* cubic feet.

The prodigal waste is now being curbed, however, either by law, business sense or common sense. The resulting supply thus salvaged has permitted the phenomenal extension of natural gas service which has marked the decade now closing. California alone reports 25,000 miles of main high-pressure pipe lines and a consumption of about one billion cubic feet daily. Fig. 1 shows

FIG. 1. HIGH-PRESSURE TRANSMISSION LINE, SOUTHERN CALIFORNIA.

one of these lengthy and expensive welded steel lines reaching out over a desolate stretch of arid country in the far west. The service north and eastward from Texas and Oklahoma, however, with extensions to Chicago, Detroit and even Philadelphia, raises figures to really astronomical values.

With thousands of families deserting coal as a domestic fuel and turning to gas, great concern has long since been expressed over the threat of exhaustion of natural gas. Mr. Ralph E. Davis, representing the American Gas Association, made a survey of gas resources in 1935. His figures for California, taken for illustration, credited that state with 5,700 billion cubic feet in known reserves.

Following this survey about 1,000 billion cubic feet were used in the state during the years 1935, 1936 and 1937. Once again Mr. Davis took stock (March 1938) and found 6,900 billion cubic feet available. Apparently somebody had discovered a lot of new gas. At this rate exhaustion would seem to belong to the somewhat distant future. Not everyone, however, shares this optimistic confidence in an indefinite supply of gas and oil. Predictions are abroad that only fifteen years of lavish petroleum riches are in prospect. We can only hope that the eventual shortage will appear gradually, giving time for appropriate conservation measures.

At great terrestrial depths natural gas dissolves freely in its chemical relative, petroleum. According to Henry's law, the solubility varies directly with pressure. At one or one and one half miles depth, common in modern oil wells, the pressures become enormous, and the concentration of the dissolved gas mounts to high values. Relief of this pressure through a well casing will not only force the oil thousands of feet to the surface, but will deliver one, two or even three thousand pounds per square inch at the casing head. The results may be spectacular if intelligent control be not practiced; otherwise the gas evaporates, again in agreement with Henry's law, affording the desired separation of gas from liquid for commercial purposes.

Usually natural gas is stripped of a small fraction of valuable light gasoline and of certain ingredients classed as "bottled gas," before long distance transmission. A chemical analysis of this stripped gas reveals a decided contrast with corresponding figures for an ordinary artificial domestic gas. The following are representative figures, subject to variation in different districts.

	Natural Gas Per cent.	(Artificial) Water Gas Per cent.
Hydrogen	0.00	36
Carbon monoxide	0.0	32
Methane and other hydrocarbons	98.0	23
Inert gases	2.0	9
Fuel value (in Brit. Ther. Units)	1,100	550

The fact that the natural fuel is mostly methane, well known as the simplest chemical compound of carbon and hydrogen (CH_4) suggested the metallic carbide theory of original formation. Water seeping through fissures in the earth's crust was thus supposed to react with the carbides. Carbon from the carbides and hydrogen from the water would yield both methane and petroleum. Substantial doubt has been cast upon this hypothesis, however, by the recent discovery that petroleum contains porphyrins, complex organic compounds normally produced by green plants and not available by any stretch of the imagination from metallic carbides. The theory of paleobotanists, who point to the vast deposits of diatomaceous earth as evidence, is

accordingly much more in favor. The diatom plant is known to have a rich, oily structure, and it only requires time to account for all of the vast oil resources of western America.

The entire absence of *free* gaseous hydrogen, and of carbon monoxide, from the natural fuel has introduced industrial as well as domestic difficulties which have made gas technologists scratch their heads during the past decade. These two gaseous substances are of low fuel value per cubic foot, although to be sure hydrogen is of high rating per pound. Unfortunately, hydrogen weighs scarcely one eleventh of an ounce per cubic foot.

For heating of buildings, or other application where calories, not high temperatures, are in demand, the natural fuel, with its greater intrinsic combustion energy, is obviously superior. When high temperature is desired, with cost as a secondary consideration, the artificial fuel is much preferable. Free hydrogen burns with great rapidity, and carbon monoxide, a fairly active fuel, seems to be inspired by juxtaposition of hydrogen in the normal domestic artificial gas mixture. When natural gas is substituted for artificial gas, the immediate deterioration in flame behavior seems to be of more concern than the less conspicuous gain in mere calories. Thus arises trouble.

One of the first to protest against natural gas was the scientific glass blower, who was unable to concentrate his flames. Methane seems to require about tenfold the burning time needed by hydrogen, and thus needs more space. It spreads out in a long "soft" blue flame. Such a fire delivered much heat to the room, but would not heat any one spot, such as a weld between glass tubes, to the necessary high temperature. The glass blower of Los Angeles, San Francisco and Chicago still has this problem, which he solves either by adding expensive hydrogen gas to his fuel line, or by enrichment of his air blast with pure oxygen. Small laboratory Bunsen burners, which handled coal-gas nicely, balked with methane.

FIG. 3. SPECIMENS OF "GAS SAVERS" WITH OTHER ALLEGED MECHANICAL IMPROVEMENTS WHICH ARE ENTIRELY USELESS.

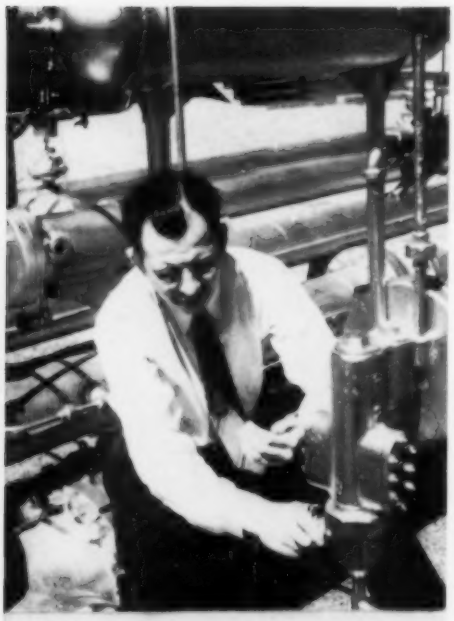

FIG. 2A. OPERATOR TIMING FLOW APPARATUS FOR INTRODUCTION OF ODORANT INTO NATURAL GAS LINES. (2B) HIGH-PRESSURE HOLDERS OF NATURAL GAS.

The flame continually blew out, since the rate of downward propagation of a methane flame can hardly keep up with the speed of the gas current rising from the burner. Anti-blowout devices now on the market have solved this difficulty.

More subtle difficulties appeared in domestic applications. When natural gas was introduced in southern California shortly after the War, the resulting confusion and accidents precipitated a public scandal. The American Gas Association, a non-partisan organization created and supported by gas producers, appliance manufacturers and consumers, proceeded promptly to meet the situation. A Pacific coast branch of their excellent research laboratory, home office Cleveland, was established in Los Angeles. The combined laboratory force has since developed and effectively introduced a host of reforms in the gas appliance industry.

Methane requires so much oxygen for complete reaction that it is often not completely burned in a gas-stove. Particularly undesirable is the cut-price domestic heater which is not large enough to handle the gas passed by the control valve. It costs an irresponsible manufacturer but a few cents to put a large gas-cock on a ninety-eight-cent heater, but the appliance, unfortunately, does not furnish enough air to the flame; nor does it deliver the air into the gas stream correctly. In some cases the flame comes too close to the walls of a skimped combustion chamber.

The result of the incomplete combustion is at least two highly undesirable gaseous products. One of these, formaldehyde, is produced simply by the substitution of only two of the four combined hydrogen atoms of the methane molecule by oxygen from the air. The formaldehyde is, of course, noxious, and gives its own warning in the form of a stale, rank or even pungent atmosphere.

More serious than formaldehyde is the carbon monoxide resulting from a slightly better, but not complete burning of the methane. This gas is highly poisonous, and has acquired sufficient notoriety in the motor-vehicle field to require no further description.

Domestic consumers who are handy with tools frequently make trouble by drilling out the small orifice which restricts the output of a small though well-made gas-heater. Such drilling may release two or three times the normal approved gas current. Worse yet, it destroys the desirable gas turbulence in the body of the burner. The small gas-mixing chamber will then not provide enough air to afford a safe mixture for combustion and carbon monoxide is the result.

Color of flame is no index of presence or absence of carbon monoxide. The presumption that a blue flame is safe is not at all trustworthy. Safe yellow flames can be produced, and exceedingly unsafe blue flames are equally common; or *vice versa*.

Methane has still further oddities of behavior. An easterner, recently arrived in California, became despondent and decided to end it all via the gas route. He plugged the keyhole and fireplace chimney, turned on the gas, sank into a chair and awaited the end. After a few hours spent in sleep which he had thought would be his last, he awoke to find himself quite unharmed. He thus confirmed the findings of Tyler and Drury of the University of Southern California medical school that natural gas is entirely nontoxic.

Still wondering when the end really was to come, the prospective suicide thought he might as well smoke a last cigarette. The results of this experiment might of course have been foreseen. In brief, the unhappy wretch found himself out in the street along with an assortment of lath, plaster and furniture fragments, but still not seriously injured. The whole affair illustrated the fact that natural gas is not only slow-burning, but also relatively slow to explode. By contrast with dynamite, which strikes a quick and shattering blow, the methane mixture, though powerful, was more like the slow-burning powder used to propel large artillery projectiles. One might thus be blown with moderate violence, although with ample reserve power, out into the street, and live to tell the tale.

The fact that methane has neither odor, taste, color nor toxicity renders natural gas too treacherous to be dispensed to the public in the pure state. Fig. 2a shows the inspection of modern equipment for odorization of the domestic fuel supply. "Calodorant," a mixture of aliphatic organic sulfur compounds, which is suggestive of decayed onions, is introduced to provide a telltale stench. It requires only one volume of this aromatic liquid to treat nearly four million volumes of gas. Although the odorant itself contains sulfur and therefore produces pungent sulfur dioxide when burned, the amount of the dioxide produced, for example, by an unvented radiant heater or kitchen stove, is far too small to be detected. Actually a bad smell from natural gas appliances which do not leak is proof of faulty construction and is suggestive of dangerous pollution of the atmosphere.

The very low liquefaction temperature of methane places this gas in the small and select group of "permanent" gases. This is a distinct commercial drawback, making it impractical to store and ship the fuel in concentrated form without the prohibitive expense of heavy cylinders like those used with oxygen. A compromise is noted, however, in the new type of storage tank shown in Fig. 2b. Even such facilities do not aid in the problem of shipping natural gas to smaller towns too distant from the gas-fields to warrant installation of expensive welded steel pipe lines.

These observations direct attention

once more to the hydrocarbon material "stripped" from natural gas before delivery to trunk pipe lines. Such material contains a few per cent. of the slightly heavier hydrocarbons propane (boiling point $-45°$ C.) and the two forms of butane ($-11°$ to $+1°$). These excellent fuels are readily liquefied under moderate pressure, and in such condensed form are finding wide application as "bottled gas." Country homes, small-town gas systems, mountain cabins, auto road camps and even buses and trucks are finding the bottled product a great improvement over obsolete gasoline appliances, especially the old gasoline stove. It should be noted that these bottled gases are of two to three times the heat value per cubic foot of methane, and special adjustment of appliances is essential.

Like model-T Ford cars, the natural gas-stove has been the victim of numerous accessory promoters. Specimens of "gas savers" and other alleged mechanical improvements are shown in Fig. 3. These devices are emphatically condemned in unanimous chorus not only by gas companies, but more pointedly by the Association. If not actually a fire hazard, the "gas saver" is usually a generator of carbon monoxide, and at best is entirely useless.

WE GROW OLD

By Dr. E. V. COWDRY

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THERE is much to learn from certain individuals who grow old slowly and gracefully. One of these was Dr. Charlotte Marie Davenport, well known a generation ago. She was born in St. Petersburg, Russia, apparently in 1825, but there is no official record of her birth. She died in St. Louis in 1936 at the reputed age of 111 years.

Married three times, at the ages of 16, 18 and 69, she bore 11 sons. Shortly before her death, to the best of her knowledge, all were alive and well. The eldest was living and 93 years old. Her third marriage was to William Davenport, a man of 21 working on the *Times* in London. They lived together happily for 40 years.

She traveled widely. In Tahiti she spent a month with her good friend, Robert Louis Stevenson. In England she gave lessons in physical culture to the late Queen Alexandra. She was photographed with Sarah Bernhardt. Coming to the United States, stacks of newspaper clippings, yellowed with age, bear witness to her reception by New York's "Four Hundred." She was interviewed in 1889 by a young reporter on the *Marion Star*, who later became President of the United States, and whose account is available for all to read. Among her pupils was Mrs. Phoebe Randolph Hearst, mother of the famous publisher. According to society reporters, she taught Mrs. Alice Lee Longworth how to hold a cigarette properly. She was an intimate friend of Admiral and Mrs. Dewey and of Joseph Pulitzer of St. Louis.

To give in a few words a picture of her life is impossible. Though some of her activities can not be proved, owing to the great lapse of time and their spread throughout the world, enough of them have been checked to lend credence to the whole.

This wonderful woman was an outstanding example of a small number of persons found in every race and in every country who do not appear to age like ordinary mortals, or else are relatively immune to disease and who do not wear out. Thus, Thomas Edison lived to be nearly 90 and did much of his best work between 70 and 80. Elihu Root, one of our greatest statesmen, lived a little more than 98 years. Titian died after he had attained his 99th year and he painted his masterpiece at the age of 85. Great age is not always coincident with intense activity and productiveness. Sometimes it is associated with placidity, with minds free from worry. In this connection we recall the statement—interesting if true—that there are more centenarians among the colored than the white population of the United States, though the absolute number of colored people is only one tenth as great. What the secret of long life is we obviously do not know. A correlated physical and psychological study of a selected group of individuals over 90 years of age is long overdue.

On the other side of the picture are those who grow old before their time. We need to know why. The processes of aging do not operate uniformly. The great difference in years between postponed aging and early aging is evidence that in nature there are some factors which modify the speed of the changes that occur. This gives us some reason to hope that eventually mankind may be able to modify intentionally the processes of aging, if only to a small degree.

The first step in distinguishing between aging and disease has hardly been taken. It is a very difficult step to take. Some

hold that arteriosclerosis is a manifestation of senescence which occurs particularly early in some persons. Others maintain that it should be considered as a disease and believe that hope may therefore be entertained for prevention and treatment. Whichever the truth may be, the conclusion is not justified that the outlook is hopeless even if arteriosclerosis is really a function of senescence, for it may prove as possible to avoid premature aging of the arteries as to prevent a disease of the arteries.[1]

For the purpose of this discussion we regard disease as the effect of injury, however inflicted, whether by pathogenic organisms, malnutrition, excessive strain or something else. Life itself is a succession of adjustments between the individual and his environment and also between his own component organs and tissues. Some of these adjustments are easily made. Like all vital activities, the ability to make them is maintained by use. Other adjustments may be only partial and may leave the individual handicapped by depletion of reserves. Some of the processes of aging are hastened or modified by disease. Consequently, one way to prolong life is to protect the organism against injury. This, after all, is what has actually increased the expectation of life in our time. It is a matter of avoiding complications that accelerate or alter the processes of aging.

Were it not for disease it is evident that some systems could, if self-sustaining, function beyond the life of the body as a whole. Friedenwald thinks the possible length of useful life of the visual apparatus is at least 120 to 130 years. Ivy remarks that the digestive tract, when not locally altered by disease, is capable, in most elderly people, of serving beyond the ordinary duration of life. Since there are also tissues whose life, useful or otherwise, is less than that of the whole body, it is obvious that aging may be hurried as well as delayed. For instance, Krumbhaar points out that the involution, or aging, of the thymus gland begins at about the age of puberty and proceeds rapidly to an advanced stage in adults. Tonsils of patients over 50 or 60 are but a slender source of income to otolaryngologists because they have become senile and shriveled. Aging of the genital system precedes generalized senility. Not only do the processes of aging differ in rate, but, in addition, many of them are interdependent, so that we must think in multifunctional relationships. We can not isolate a single aging process in "pure culture" and study it alone.

Within the body the aging processes operate in many different environments. It has been estimated by Krogh that the vascular capillary endothelial surface amounts in each one of us to about 6,300 square meters. In other words, it is equal to the surface of a plot of ground about an acre and a half in extent. There are certain well-established regional differences in permeability, and in any area temporary variations may occur. Consequently, the exchange between the blood stream and the extravascular fluids is not uniform. The tissue fluids of avascular tissue (cornea, epidermis, cartilage, etc.) are more withdrawn from this great sheet of endothelium and of blood supply than those possessed of a rich capillary network. Diversity in activity of cells in different tissue fluid environments is not likely to be without influence.

[1] It is interesting that the Josiah Macy, Jr., Foundation passed from a survey of the problem of arteriosclerosis to an equally detailed study of aging from the biological and medical points of view. Twenty-three investigators, drawn from many specialties, cooperated in the first (Macmillan, 1933), and twenty-five in the second (Williams and Wilkins, 1939). The Union of American Biological Societies and the National Research Council, together, sponsored a conference on aging held at Woods Hole in the summer of 1937 for which provision was made by the Foundation. A committee of the council has been actively at work for several years trying to foster research.

We think at once of differences in fluid consistency, hydrogen ion concentration, mucins, mineral salts, polysaccharides and hormones. Local factors may obviously accelerate, retard or modify the processes of aging. Therefore, we have to look through the screen of disease, identify the aging processes as clearly as possible and search for clues by noting their behavior in different environments.

Decrease in *water content* is perhaps the most fundamental of all aging processes. The individual shrinks both in weight and in stature. The latter must be taken into consideration when we compare our height with that of our grown-up children. In general, they are conspicuously taller, but many of us are a little shorter than we were at their age. Probably not unrelated to this progressive dehydration is granulation or *condensation of colloids*. The capacity of a newly formed, or young, colloidal gel to bind water decreases with age. With loss of water the dispersion of the colloidal particles becomes less, and elasticity and flexibility decrease. This phenomenon accounts for the aging of elastic colloidal fibers in the walls of blood-vessels. H. Gideon Wells is of the opinion that arteriosclerosis depends primarily on changes in the elastic tissue that reduce its resiliency and lead to arterial dilatations. Others do not agree, but the ancient dictum that man is as old as his arteries and the importance of the "vital rubber" are not lessened by recent investigations. The loss of elasticity and breaking up of red blood cells is in all likelihood a similar phenomenon. Indeed, we are only beginning to appreciate how wide-spread the aging of colloids may be in the body and how different in different tissue fluid environments.

Decrease in *replacement* of tissues is another change that comes with aging. In a 60-year-old man a wound takes five times as long to heal as a wound of the same size in a 10-year-old child (du Noüy). Replacement depends on ability to form new cells from old ones. Fibroblasts and capillary endothelial cells seem to retain this property as long as they live, or nearly so, whereas nerve cells are among the first to lose it.

We have spoken about the unequal longevity of systems and tissues. Carrying the analysis farther, we need more light in the relative life span of cell types. The urge to replacement will also have to be determined, for this may depend upon the physiological reserves. This line of investigation is essential, but will be tedious because the frequency of cell division will have to be computed. It will be heavy spade work.

It is common knowledge that after maturity *adaptability* decreases with age. An old person adapts himself less quickly and effectively than a young adult to heat or to cold or to an onrushing motor car. There is a depression in adaptability to almost all changes, whether of external or internal origin. Basic perhaps is a curious kind of faltering or indecision in regulation. Cannon has shown that with aging the homeostatic mechanisms become more and more restricted in their ability to maintain the essential stability of the blood. We need to dig deeper and to unearth the aging processes responsible for this restriction.

Very fundamental are hereditary factors. Not all individuals approach old age equally endowed. Operation of these hereditary factors is often masked, as are the normal processes of aging, by the added complication of disease and accident. The difference is that the hereditary factors are spread equally throughout all the cells of the body (except the sex cells), though response is limited.

These purely physical, chemical and biologic mechanisms of aging are just beginning to be studied. There are vast fields as yet totally unexplored. Nearly equal is our ignorance of the psychiatric, emotional and sociological aspects of aging.

Few people anticipate growing old with any particular relish. Some strive against it with all their might and main. What do they fear? In many cases it is not death that they dread. They see their friends drop off one by one. They write more and more letters of condolence until the task becomes almost mechanical—an unpleasant duty. They know that death is inevitable, and some of them even court it as a delivery from unhappy situations. As G. Stanley Hall said, "to have once deliberately oriented ourselves to death before our powers fail gives us a new poise, whatever attitude toward it such contemplation leads us to." This is sound common sense.

Lewellys Barker reminds us that only rarely do old people know, when on their death beds, that they are about to die. Sir William Osler made a careful study of the modes of death and the sensations of the dying in the case of some 500 persons. He stated that about 90 of the 500 suffered bodily pain or distress, 11 showed mental apprehension, 2 were positively terrified, 1 expressed spiritual exaltation and 1 suffered from bitter remorse. But, he continued: "the great majority gave no sign one way or the other; like their birth, their death was a sleep and a forgetting."

To fear pain, however, is only natural. Pain cries aloud for relief, and in old age powers of adjustment and recovery wane. It is scant comfort to be assured that sensibility to pain decreases in extreme old age, though it seems to be a fact. A realistic attitude is indicated. Looking ahead from the age of 60, the percentage of chances of death from different causes, according to the 1930 U. S. Census, are as given in Table 1.

TABLE 1

	Male	Female
Cardiovascular renal diseases	59.85	59.58
Cancer	10.71	11.90
Accidents	4.53	4.55
Influenza and pneumonia	6.55	7.28
Tuberculosis	1.75	1.34
Diabetes	1.74	2.91
Other causes	14.87	12.44

On adding the first two items together, we find that almost three in every four individuals of 60 will die from cardiovascular-renal disease or from cancer. Much can be done by prevention, early diagnosis and treatment. Yet how common is the attitude "where ignorance is bliss 'tis folly to be wise." Millions, however, suffer despite reasonable precautions. I am confident that in the future social order a perfectly proper and legal way out will be found for those who are incurably sick and racked with pain. To prolong their suffering is, like war, a misuse of science. Just at present we remain, in this respect, in the Dark Ages.

But what a great many old people fear more than death or illness are long years of uselessness, living on the bounty of their relatives and friends. In short, they see the walls closing in on them, and they doubt their ability to adjust themselves to the changing conditions. The prospect is really not so gloomy, provided medical science marches on and continues to relieve inevitable aging from the complicating handicap of disease. We may not agree with Browning:

> Grow old along with me;
> The best is yet to be;
> The last for which the first was made.

But there are even now some advantages for the healthy among the aged. Emerson has said that: "At fifty years, 'tis said, afflicted citizens lose their sick-headaches"; and "'tis certain that the graver headaches and heartaches are lulled once for all, as we come up with certain goals of time. The passions have answered their purpose; that slight but dread overweight, with which, in each instance, Nature secures the execution of her aim, drops off. To keep man on the planet, she imparts the terror of death. To perfect the commissariat, she implants in each a certain capacity to get the supply, and a little oversupply, of his wants. To secure the existence of the race she reinforces the sexual instinct,

at the risk of disorder, grief and pain. To secure strength, she implants cruel hunger and thirst, which so easily overdo their office, and invite disease. But these temporary stays and shifts for the protection of the young animal are shed as fast as they are replaced by the nobler virtues."

That relief from many responsibilities does pave the way for continued usefulness is sure. With aging there is an increase in conservatism. Hasty decisions are not so frequent. Long experience gives perspective, and interest has a marked tendency to expand to the city, the nation and the whole world. Activities which do not demand great physical effort can be carried on without impairment, and more leisure time is usually enjoyed. How can these and other assets be put to the best possible use?

The first essential is to plan in advance for old age. As a rule the only effort which men and a few women make is to save enough money to provide for their old age. They suffer the greatest shock of their lives when they are pensioned off or are discharged to make places for younger persons. They have not cultivated any useful activities to take the place of those of which they have been suddenly deprived. They soon realize how crushing is inactivity. For most women it is a little different. The majority have their home and children to look after. Since the children leave one by one, the transition is gradual and home cares remain to some extent. A plausible case can be made out for the average longer life of women on the basis of the relative absence of this sudden demand for adjustment.

How can we best make this running start which will carry us over this great change in our lives? We must both seek help and help ourselves. Great assistance can be obtained from the psychiatrists, who study personality and its adjustment. In the modern world old-age guidance is needed as well as child guidance. Help is also to be secured from others who have made the adjustment satisfactorily. Such people are beacon lights in every community. It is for them, at our urgent request, out of their wisdom and experience to tell us how they do it. This is not the least of the many significant contributions to society that they can make. With real vision Barker says that "The psychology of normal old age is probably never very well understood except by those who, remaining healthy, live to be old themselves." The trouble is that these leaders extend the helping hand not to their immediate followers, who need it most, but to the rising tide of starry-eyed children.

After all, as we grow old, self-help is the mainstay. There is no denying the fact that in some ways we become as little children before we pass on. Little children prattle on and on and nobody pays much attention. With increasing age there is a growing tendency to talk too much. The feeling of inadequacy grows, as less and less notice is taken of what the elders say. Compensation urges them to talk more and offer gratuitous advice. Advice falling on stony ground brings forth little fruit, but when it falls on receptive ground it develops without insistence by the sower.

Except for disease, this feeling of inadequacy is the heaviest burden that the aged bear. The most effective preparation for advanced years is cultivation of some line of activity which can be carried on as we become more and more physically feeble. The really happy aged person holds his head high and consequently avoids a feeling of inadequacy because he or she is able to do something extremely well. It makes very little difference what this something is as long as its value is appreciated by others. To compensate for necessary restriction of activity, specialization is clearly indicated. And the beginning must be made before the handicap of years is felt.

The social *magna charta* of the aging

individual and of all mankind has been written by John Dewey in the following words, ". . . I am unable to see how the basic human problem can be solved without social changes which ensure first to every individual the continued chance to have intrinsically worth-while experience and secondly provide significant socially useful outlets for the maturity and wisdom gained by experience." It is up to the community to provide this chance or opportunity, but the individual must not be passive. On the contrary, he must actively seek the opportunity, not only for himself but for others, because service does not necessarily cease with old age, but is, or should be, co-extensive with life.

In the days of Washington and Jefferson, when the nation was born, the average age of white persons in this country was little more than half of what it is to-day. The increasing life expectancy of the nation is dramatic, as shown in Table 2:

TABLE 2

1789	New Hampshire and Massachusetts	35.5	years
1850	Massachusetts	40	"
1900	United States	50	"
1920	United States	55	"
1930	United States .... a little over	60	"
	Possible in near future (Dublin)	70	"
	Maximum (Dublin)	75	"

Life expectancy is the average number of years that babies born in a particular year will live, provided the mortality rate remains the same during their lives as that calculated for the year of their birth. The life expectancy has progressively increased as a result of decrease in the mortality rate, and probably has not yet reached its peak.

Let us now take up the alterations that have occurred, and are likely to occur, in the percentage of different age groups in the total population of the United States. Table 3 is based on investigations by Dr. Louis I. Dublin.

TABLE 3

Year	Ages 0–4 Per cent.	Ages 5–19 Per cent.	Ages 20–44 Per cent.	Ages 45–64 Per cent.	Ages 65+ Per cent.
1850 ...	15	37	35	10	3
1870 ...	14	36	35	12	3
1890 ...	12	34	37	13	4
1910 ...	11	31	39	15	4
1930 ...	9	30	38	18	5

It follows from the figures in the first column of Table 3 that there has been a steady and rapid decline in the relative number of children under five years of age, the percentage having decreased since 1850 to almost half its value. No less interesting and important is the fact that the relative number of persons exceeding 65 years has almost doubled in the same interval, while the percentage of the population in the productive years 20–44 has remained about the same. It is chiefly this group that must provide care for the decreasing number of young and the increasing number of old people.

Dublin mentions the possibility that the standards of living may fall, owing to the increasing burden on people in the productive ages. But we must not forget the changed status of women. In the past 50 years it is said that the percentage of gainfully employed women has increased from 14.5 to 22, and the end is not yet. This means that the strain on this age group is being relieved because the burden no longer falls almost wholly on the approximately 50 per cent. of males in it.

The age 20 to 44 is the age level of active employment, but productive labor is carried on by some older as well as by some younger persons. However, the relative number of older workers, though increasing absolutely owing to the change in population structure, is being decreased by earlier retirement, and the relative number of the younger workers is being decreased by child labor legislation and a greater number of years devoted to education. This bearing down upon the productive age group

by the elders above and the bearing up by the young below, so that the production group is caught between two millstones, does not at first sight appear to be a great disadvantage, because, owing to improvements in means of production, fewer workers are needed.

Already, however, the strain upon those who are employed is increasing because the unemployed, as well as their juniors and seniors, must be cared for. The juniors are decreasing slightly in relative number, but our ideas are more extravagant than those of our parents as to what children should have. The crop of palatial public school buildings rising throughout the land bears witness to this change. The dwindling band of producers must pay the piper for youth. It must also provide old-age benefits for an actually increasing number of aged. Legislation is passed not so much by inviting the votes of the aged as by suggesting to the producers that they, individually, may wish to be relieved of responsibility by "passing the buck" to the government. To obtain "social security" the industries, which employ labor, are taxed almost to the point of extinguished profits.

Certainly the situation is already unbalanced. It involves conflict of interest between producers and consumers. The first, as we have intimated, are in the minority and must serve not only themselves but all the rest. To partly compensate for this handicap, the New Deal protects the producer (farmers and others) by causing an artificial scarcity and by thus raising the price level of their products at the expense of the larger class of consumers. Among the consumers are many unable to pay higher prices for needed food and clothing. These suffer because efforts to increase their purchasing power by unprecedented government spending have not in general been successful. Money has not made its way into the right pockets. The results of a Gallup Survey (*Globe-Democrat*, April 2, 1939) show that half of town and city dwellers are already on relief or near it. The state, in turn, derives its funds from the hard-worked producers, and the vicious cycle is complete.

The rise in age level of the population not only increases the strain on the small band of producers but also brings about a shift in character of production. As an example of necessary adjustments in an aging population, wise shoemakers will not blame the New Deal because the sales of children's shoes fall off by the million; rather will they pay increasing attention to the manufacture of shoes suited to older people.

In respect to health services, increase in length of life intensifies certain problems. Curiously enough, the pediatricians are among those most interested. It is doubtful whether they have yet felt the decrease in number of children because the service per child is increasing. Although children are obviously given better medical care than ever before, there is still much room for improvement. The 1930 census revealed fewer children under five than the previous census, and, what is even more significant, fewer under five than in the next group of five to nine years. In other words, the supply of children was even then falling off. Later, in 1938, there were, according to Fairchild, more than 1,600,000 fewer children under ten than five years earlier. Already there is a noticeable decrease in the number of young children entering many public schools.

Cases of those diseases to which people over 45 are heir are increasing as they themselves increase in relative numbers. Thus, in the age group from 80 to 89, inclusive, 66 per cent. of males died of cardiovascular renal diseases and 64.3 per cent. of the females. The deaths from cancer reached their peak at 22.4 per cent. for females aged from 50 to 59, and at 13.4 per cent. for males aged from 60 to 69. More important, however, is

the mental care of the aged. They require expert guidance just as truly as children do. Maladjustment, or lack of compensation by new activities for the giving up of others to which they were accustomed, is, as we have said, the main burden of the aged. The state of mind which this maladjustment engenders is not without harmful influence on whole families.

At present the number of persons over 65 relative to the total population has approximately doubled since the Civil War. Obviously, this change has brought about a profound difference in family life—twice as many father-in-laws and mother-in-laws to be given useful work in the home. And the numbers of the latter are increasing more rapidly than of the former, for a majority of old people will be women, because female mortality for the aged is considerably lower than that of males. The increase in the percentage of aged people, coupled with the realization that they are still potentially very useful members of the community, will inevitably but gradually bring into being a new group of specialists in medicine—the geriatrists. A thorough knowledge of internal medicine plus a lively interest in personality and its problems will be necessary for these specialists. The mental aspect of treatment of the aged looms large. Only when there is a demand for it, will appropriate training be provided in the medical schools. The dictum that "The boy is not a little man" is true, for he differs functionally and structurally from a man, not merely in size. An old man is not simply an unwanted adult. He differs as much from a person in his prime as a boy does, but in ways that we do not yet fully understand.

In education, also, the social order will have to become adjusted to the needs of an increasing fraction of the population. We have mentioned the shrinkage in numbers of young school children. We have seen adult education come of age. It is only a matter of time before far-sighted book publishers will make a careful study of the tastes and needs of older people and cater to them. With age there usually comes more leisure and time to read. As consumers of books, they are to be reckoned with. And, perhaps, some leading university will recognize the fact that persons past middle age still wish to keep abreast of the times.

In the shaping of national character the progressive alteration in population structure is certainly not without influence. We can not expect our nation to-day to behave in the same way that it did at the time of the Revolution. Dublin, looking to the future, remarks that "conservatism may become much more characteristic of our thinking than it is to-day. There may be expected fewer radical departures from accustomed ways and suggestions for new forms in all phases of life will probably meet with increasing resistance." Dewey has discussed this matter rather fully. He writes ". . . conservatism increases with age, so that in the degree in which the older group expresses itself politically we have the curious and indeed ironic condition that at just the time when measures of social readjustment are most needed, there is an increasing number of those whose habits of mind and action incline them to resist policies of social readjustment." However, it is open to argument whether this condition is not so much "ironic" as fortunate. Recent history seems to demonstrate that the greatest danger in social readjustment is, as on the highways, the rate of speed. To Dewey's reminder of the prospect of one third of the population over 50 years of age, we counter with the statement that according to the best available statistics the safest age for driving a motor car is fifty. In my opinion, the rising age level is a blessing because experience teaches, and it will supply a brake.

THE ROLE OF THE FUNDAMENTAL SCIENCES IN MEDICAL PROGRESS

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THE mysteries of the starry heavens and the urgencies of human pain seem to have made man pause and ponder at the very dawn of reason. At any rate, the earliest accounts we now have of man trying to understand himself and the universe deal with astronomy and with human sickness. Medicine is sometimes spoken of as the mother of the sciences. The earliest, sporadic achievements in medicine here and there among the peoples of the earth, such as the use of quinine against malaria by the South American Indians, the use of toad skin for dropsy and vaccination against smallpox by the Chinese several hundred years before Jenner, were steps in the control of rather than in the understanding of disease. The Greeks had Galen, and Galen was on the right road, but he had few real followers for a thousand years. Hence, medicine in the sense of discovering the causes and working out the means of controlling and preventing human ills dates back only a few hundred years. And the ascending curve of achievements in medicine closely parallels the progress in the fundamental sciences of biology, chemistry and physics. This is not an accidental parallel, as we shall see. Nor is the parallel explained entirely by the fact that all science is one in method, and the human brain is the catalyzer of them all. The reason is: Biology, chemistry and physics have furnished and will continue to provide many of the data, the hypotheses and the tools necessary for the next step in the unending fight against disease.

Which are the "fundamental sciences" and what are their rôles in medical education and medical practice? Human anatomy, animal physiology, biochemistry, bacteriology and pharmacology are historically the legitimate offsprings of medicine, and these sciences still dwell largely on the old paternal homestead. Perhaps it would be more correct to call biochemistry an adopted child, adopted from chemistry. They are now an integral part of modern medical education, medical practice, medical research, hence included in the term medicine. But human or animal physiology, at least, is as important in our secondary and college education as it is in medical education. We are slowly realizing that at all stages of education the traditional "three R's" must be rounded out with an "H," which stands for, not hallelujah, but *Health*. And health education is more than the establishment of so-called health habits, like love for the tooth-brush, fear and hatred for gin and whisky. Education is more than habit formation, more than cerebral canalization to the centers for love and hate. Education means understanding. Health education means understanding the living body, the living machinery of man, the known causes of disease or ill health and the known ways of keeping fit. This is the contribution of the medical sciences to primary and general education in our democracy, as yet only partially either sensed or achieved. The imparting of the traditional three R's to youth is by the nature of the case largely a matter of dogma and drill. But drill and dogma are largely futile in health education. Health education can not be achieved by the memory route, as can the alphabet, the multiplication table or the church catechism. Health education involves the

ABC's of science and the scientific method, both on the part of the teacher and the pupil, that is, controlled experimentation, rechecked observation, repeatedly verified cause and effect relations. It is the development of the skill in finding "facts," the use of reason based on facts rather than an exercise of faith based on unverified dogma.

Botany. What about the other biological sciences, botany, zoology, and the union of these two, with a sprinkling of geology, and climatology, and constantly implemented by chemistry, namely, agriculture? Do these play any rôle in modern medicine? Those who look no deeper than to the surface of things may say that the potato and the pine are so different from man, the self-styled "crown of creation," that the scientists who deal with the former can not possibly produce anything of importance to human medicine. Let us pause and see. In the first place, the plant groups: Bacteria and fungi are common agents of debilitating and deadly human disease. But more fundamental still: The essential machinery of reproduction, growth, nutrition, respiration, heredity and death is the same in the plant as in man. The plant is subject to disease and death, much as man, from defective heredity, malnutrition, poisons, bacteria, animal parasites and viruses. Plants take up from the soil and concentrate in their seed and other structures substances toxic to man, such as selenium and fluorine. Man secures much of his food from the plant kingdom, and the quality of that food (for example, vitamins, iodine, iron, the nature of the proteins, etc.) is of great significance to human health. Many significant medicines, like quinine, ephedrin and digitalis, are manufactured by the plants. But, perhaps, it is in the studies in cell life, on the machinery of heredity and on the mechanisms of immunity to disease in plants that the science of botany attains its greatest significance to human medicine. So the botanist is more than a "fellow traveler" to the physician; he is a fellow worker, that is, if the botanist will have it so. We who labor in the field of human and animal health and disease have for fifty years been greatly puzzled by the seemingly abrupt and adult appearance of the complicated hormone machinery, specifically beginning with the vertebrates. The riddle has been solved for us in the last ten years, at least in part, by the plant physiologist. Many of these hormones are present and working in the tissues of the plant. In the vertebrates their production has become confined to specific organs or glands. It is no longer so perplexing to find that the pussy-willow produces chemical messengers not so different from those produced by the ovaries of women and the testes of men.

Zoology. It is true, man can get tuberculosis and undulant fever from the cow and the goat, trichinosis from the hog, deadly glanders from the horse, Asiatic plague from the gopher and the rat, tularemia from the lowly rabbit, tapeworm from the fish, spotted fever from the wood-tick, malaria and yellow fever from the mosquito, typhus from the louse and deadly fever from the parrot, and this is just the beginning, not the end of the list. But these are not the things that make zoology so important to medical advance. The significance of zoology to medicine can be sensed, even by intelligent laymen, in the following facts:

(1) The fundamental identity of body structure and body machinery in man and animals.

(2) The essential identity of the machinery of heredity in man and in animals, and the importance of heredity in the susceptibility to disease, in the stability of the mind, in growth and longevity, etc., of man.

(3) The frequent appearance of spontaneous diseases in animals, such as infec-

tions, cancer, dietary deficiencies, liver, heart and arterial diseases, brain and body failings in the aging process, etc.

(4) Experimental diseases, such as infections, the numerous and important dietary deficiency diseases, diseases due to deficiency or excess of the hormones in the body can be induced in the animals, domestic and wild.

(5) It is safer and faster to standardize new and old drugs on animals rather than on man.

The significance of these five zoological categories to progress in medicine are almost self-evident. Man is an animal. Some people believe, others hope, he is also something more. At times man behaves as if he were something less. There may still be some uncertainty both as to facts and factors in biologic evolution, but the essential identity, in health and in disease, of the brain, the heart, the gut, the lungs, the liver and the kidneys of man and the animals is as certain as the product of two times two. Unfortunately, we do not transmit our own understanding and knowledge with our germ-plasm. We can give our children only the capacity and the facilities to learn. No matter how great our medical knowledge to-day, our children of to-morrow start exactly at zero. So each generation of medical students must secure its fundamental training in the nature of health and the nature and control of disease on the animal, living and dead. History tells us that whenever we succeed in reproducing a baffling human disease in the experimental animal we start to go places, and go fast. The fundamental experiment of the immortal Pasteur was on sheep, not on men. Some serious human ailments can, at present, not be diagnosed with certainty without resorting to tests on living animals. The mouse and the rat, the guinea pig, the dog and the monkey are necessary material in the modern medical school, the modern hospital, the modern medical research institute. Here I pause to remark that all these agencies of medical progress in these United States to-day find themselves hampered by inadequate animal quarters for medical teaching, medical research and medical service to man. Even the wisest medical statesman could not foresee the expanding needs of this type of medical aids for to-morrow. Every unit of the commonwealth—city, county, state and nation—must nurture, not hamper, this important avenue of medical advance, the use of animals in medical education and medical research.

Psychology has succeeded in cracking its confining carapace, traditional philosophy, and as a biologic science has rendered and will render great service to medicine in the direction of understanding man, both in health and in disease.

Paleontology and *Anthropology* may shed light on the antiquity of disease. These same sciences may some day tell us how long ago our ancestors were something less than apes, and hence how long the road ahead till we, their children, shall have earned the name *Homo sapiens.*

Preventive Medicine is the natural child of fundamental medical research and social statesmanship. If in many medical schools this child is anemic, it mainly is due to lack of medico-social statesmanship. As regards a really comprehensive and effective disease-preventing program for all the people, some progress is being made with smallpox, typhoid fever, malaria, tuberculosis, syphilis, dietary deficiencies, etc. But by and large, the perplexities confronting the students of nation-wide disease prevention to-day seem as discouraging as did the control and the cure of individual sickness to the doctor of a hundred years ago. Ignorance, irresponsibility, poverty and greed are formidable obstacles to the health of the individual. Nation-wide, these seem insurmountable,

except to the few of us who may be killed but never conquered. But the physician alone can not win this war, nor can it be won without him. This program involves the regulation of industry by the needs of health. Above all, it involves a very high level of education and sense of social responsibility on the part of every citizen. It will not be achieved by law or force. If and when it comes, it will be by the action of free men, based on understanding. It involves adequate food production (hence *agriculture*) and distribution (hence *commerce*), adequate housing, adequate work for all who can and will strive, and the sterilization of those who can not or will not do their share of the world's labor.

Chemistry. We have volumes on the role of *chemistry* in medicine, and I have a feeling of mental paralysis, not because of paucity but by the very abundance of material and illustrations. Man is a chemical and physical machine. Some like to think he is more than that. Maybe so. Some day, when we know more about chemistry and physics, we may actually know. But that the same chemical substances and chemical energies operate in man as in the rest of the universe is now abundantly proven. We owe to chemistry many of the methods necessary in the isolation, analysis and comprehension of the processes of health, as well as disease, in the identification of chemicals that cause disease, in the manufacture and purification of chemicals that aid both in the prevention and in the cure of disease. The microscope revealed the cell as the present unit of life, but it remained for chemistry to reveal its composition and its energetics. Just picture to yourself where the physician and his patient would be to-day, without our present knowledge of the chemistry of respiration, of foods and digestion, of blood and urine, of growth, of hormones, of bacterial toxins and immune bodies, of such important remedies as insulin, arsphenamine, sulfanilamid and vitamins. Several hundred years ago the brilliant but erratic Paracelsus said: "The true use of chemistry is not to make gold but to make medicines." To-day we would say: The true use of chemistry is not to make gold, not even to make medicines, but to aid man in the understanding of his own life and the universe about him.

Physics. To-day the line separating chemistry from physics is very faint, indeed. These two sciences unite in probing the atom, in harnessing the electron. All life processes in health and in disease involve or consist in chemical change, and every chemical change has physical concomitants. The human eye, the human ear are in fact physical machines, worked by the physical forces of light and sound. The discovery of electrical energy did more for biology and medicine than it did for industry. For millions of years there has been going on in all living things an adjustment to such physical factors in the environment as barometric pressure, oxygen concentration, humidity, heat, light. And there is no good reason to think that this is the end of the list. Where would medicine be to-day without the microscope? The x-ray form of physical energy discovered just a minute ago, considering man's terrestrial time, is very nearly as essential in the diagnosis of gastric ulcer, tuberculosis of lung and bone, tumors, rickets, brain abnormalities, diseases of the gall bladder, the kidneys, the heart and the blood vessels. Physiotherapy is in its infancy. In our present scanty understanding of cancer, x-ray and radium are helpful aids in its control. The ingenious contrivances given us by the physicists who perfected the radio have yielded a new method for studying disorders of the brain. We need say no more. If these examples are not convincing that advances in chemistry and in physics constitute the very air, water

and food requisite for advance in medicine, I might as well save my time and yours. A few years ago an able physicist told me that in his opinion all physicists should abandon their research in pure physics, and for the next generation focus their brains and skill on biology and medicine. In my humble opinion, that would be a great mistake. Let a Compton and a Millikan continue to capture and dissect the elusive cosmic ray, from the top of the stratosphere to the bottom of the ocean. In the long run, that will be of greater service to medicine than if such men, almost innocent of biology, should turn their attention to cancer. We need more, not less, brains in every science.

But the chemist and the physicist have an easier task than the physician. In their dealings with atoms and energy, they are the least hampered by the human equations of ignorance, superstitions and misunderstandings of their fellow men. Not so the doctor. When he tries to protect children against smallpox or tries to get an understanding of the maiming and killing disease, high blood pressure, by experiments on dogs, peculiar people, like the anti-vaccinationists and the antivivisectionists, say nay, nay, with all their voices, all their votes and all their wealth. And yet, the doctor must carry on.

So we see that medicine, specifically the science of medicine, is a hungry, omnivorous, but, I hope, humble and grateful bantling. He leans heavily on all science, but specifically on biology, chemistry and physics. Like the ameba and the sponge, medicine absorbs nutrients from the boundless sea of science and is doing its utmost to organize this growing mass of facts and skills to the understanding and the service of man.

If this brief survey of the rôle of the fundamental sciences in medicine is even approximately correct, several consequences seem to follow, consequences so pregnant in their portents as to make us all pause and ponder:

(1) *Medical education and medical research are becoming increasingly complex, time-consuming and costly.* But we can see no other way. There are no short cuts.

(2) *The conscientious practice of modern medicine is becoming so complicated and costly as to almost exceed the intellectual capacity of the ablest men.* Again, I see no cure for this. Who shall bear the necessarily increased cost of modern medical service, the individual or society? I do not know the wisest way.

(3) *No university will be able to maintain a medical school of distinction, without great men also in biology, chemistry and physics.* And pygmies in the humanities and the social sciences aid medicine not at all.

I would put first things first in this field, and that is *able men.* In the past third of a century I have listened to endless discussions on the minutiae of the medical curriculum. I have seen drives for bigger and better teaching and research hospitals, bigger and better teaching and research laboratories. I have listened to plans for "coordination of research" from people who do not have their milk teeth, not to speak of their wisdom teeth, of research. Talk comes easy. But real medical research and conscientious medical practice take everything that the ablest of us can deliver. It is not a union schedule of forty hours a week, but a sweating proposition of eighteen hours a day. And some universities, some university medical schools are still in the "stone age," aided and abetted by both public and private funds. Look at the piles of brick and mortar, steel and stone towering towards the sky on almost every state and city university and college campus in our country the past ten years, largely through federal funds. In the mean-

time, how many new farthings have been invested in men in these institutions, in first-rate men? Look at the record, and weep! To my knowledge, big buildings and small men have never made great institutions. But big men have frequently added mightily to our understanding of life in health and in disease, in primitive surroundings and with meager equipment. For years and years, it was my great privilege to walk and talk with Michelson, Millikan, and Compton, Neff and Stieglitz, Chamberlin, Moulton, and Moore, Whitman and Lillie, Loeb and Coulter, Billings and Hektoen, David Starr Jordan and William Rainey Harper. Only two of these challenging spirits were medical men. If I have in any way contributed to medical education and medical research, this is due largely to the example and the challenge of such men.

Fifty years ago the echoes of the red man's war-whoops had scarcely died on our western prairies, and the bleached buffalo chips still littered the plains. The sod hut of the first settler and the song of the ax in our primeval pine forest to the north were harbingers of a new era in man's conquest of nature. It takes labor and sweat, patience and wisdom to conjure forth the fruits of the soil and the iron from the bowels of the earth.

But it takes infinitely more labor, more wisdom, more patience and more cash to establish and maintain that social and intellectual soil and climate necessary for the development of the finest qualities of men. Science, medicine, to-day and to-morrow, are a part, but only a part, of that soil and climate. The farmer, the man in the mart, the teacher, the statesman can also significantly accelerate these processes, but only if the seed sprouts in the understanding of the common man. When every farmer leaves his acres a little better than he found them; when every worker leaves the imprint of human honesty and human dignity on every task performed, however humble; when every lawmaker helps to render human relations a little more equitable; when every judge leaves his court a tradition of a little more justice; when every doctor, every teacher, every investigator work more for love and less for hire; when every statesman leaves the path of compromise, conciliation and approximate justice a little more accessible and secure, we shall have something greater than fat cattle, marble palaces, tall buildings, radios defiling the pure ether with black lies and mighty airships spewing pain and death on women and children. Even then, we shall not have perpetual health, not even perpetual youth. But we shall be well on the road to earn the designation: *wise men*. We shall still struggle for life and light, but shall have left behind the follies, the fears and the fights of the jungle.

THE PRACTICE OF MEDICINE IN TUDOR ENGLAND

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I

FAR too much has been written and published about the brave and novel world of sixteenth century England. A recent illegally anonymous article (from the historian's point of view) revealed to the reader that, upon the subject of medical history at least, the writer's imagination paid large and immediate dividends. We historians, most of us rejoicing heirs of logical precision, are left inert and vaguely sad when confronted with something that professes to be "history," and is not. We may grow acid and austere when pseudo-historians, who know a few of the tricks of our laboratory, release their arrogant and unsubtle assertions upon the world. We may attempt desperately to keep our wills effective and our nerves in order and seem content with a staunch denunciation of lesser breeds without the law. We may seek security in flight. Finally, we may attempt to explore more fully the subject that has presumably already been discussed (in our circles we describe it felicitously as "a re-examination of pertinent data") and arrive at a new thesis that is more or less defensible.

II

The names of distinguished men of medicine who lived in the age of the Tudors seem to slip easily from our tongues. We have noted them in a multitude of texts and monographs. Thomas Vicary, William Clowes, Thomas Gale, John Caius, John Banister, Thomas Cogan, Andrew Boorde, Christopher Salmon, William Bullein, these are a fitting part of the century of More and Colet and Erasmus. We may perhaps include Buttes and Bentley and Ayliffe, who frown proudly from Holbein's famous picture of the physicians of Henry VIII. Students of the history of medical science will find it difficult, however, to extend the roll of honor without impressing Baker or Gerard or the contemptible Whetstone from the streets. We are surprised, for we had concluded the great Renaissance physicians were legion. Now they appear but a few digits in the crowd. There is, of course, some truth in the point of view accepted by fond lovers of the glorious and golden age of the Tudors. There were physicians of no mean stature. There were advances in medical science and pubilc health.

On the other hand, there is much more truth in another sort of view. The skilled and learned physicians in Tudor England were few. The competent surgeons were few. Most of these depended for their skill and knowledge upon their studies in Padua, Leyden, Basel, Montpellier and Heidelberg. The universities did not provide a sufficient number of practitioners for the public. The larger part of the practice of medicine was in the hands of men who possessed few pretensions to medical knowledge and, frequently, even fewer to respectability.

The influence of the Renaissance in the field of medicine in England was not significant. The ferment caused upon the Continent by Vesalius's "De Humani Corporis Fabrica" raised but feeble echoes, even in Oxford, Cambridge and London. Little was known of Paracelsus but his name. The authority of Galen may have been weakened within a restricted circle but to most he still remained the "prince of physic" and the

"lantern of surgeons." Considerable and varied evidence indicates that England took no active part in the medical Renaissance of the Continent until the appearance of Harvey's "de Motu Cordis" in 1628. In the field of plague medicine, as Professor Charles F. Mullett has argued elsewhere in the pages of the SCIENTIFIC MONTHLY (April, 1937), the advance was more marked. English medical achievement here lies only in the field of preventive medicine. Once the pestilence had struck, in the words of Thomas Nashe's lament, "physic himself must fade."

III

Before the days of Mayerne and Harvey medical students in the universities usually had clerical status. In 1539, largely because of "the bustling of the university up and down" in matters of religion, John Caius left Cambridge to seek peace at Padua. There the great Vesalius taught him anatomy, a subject frowned upon by the ecclesiastics at home. Upon his return to England, Caius lectured before Henry VIII, became physician to Edward VI, Mary and Elizabeth. Meanwhile he wrote the "Liber de Ephemera Britannica" (1555) and a curious tract "On English Dogs" (1576). Much of what Caius says in the latter essay seems a little obscure and it is unnecessary to do more than suggest the general content.

> Little dogs are good to assuage the sickness of the stomach, being often times thereunto applied as a plaster preservative or borne in the bosom of the diseased and weak person which effect is performed by their moderate heat. Moreover, the disease and sickness changeth his place and entereth—though it be not precisely marked—into the dog, which is an untruth, experience can testify.

At the University of Cambridge, where he was to give his name to a college, Caius lectured and dissected until the "idolatrous objects" were burned in the college quadrangle by students who, mindful of the St. Bartholomew's Massacre, in 1573 denounced the Roman Catholic doctor of physic.

The career of Caius may stand as illustrative of the biography of several of his contemporaries. There were, of course, many who had no opportunity to study with the masters on the Continent or, like the erratic Andrew Boorde, physician to Henry VIII and author of the "Breviary of Health" (*c.* 1542) and the "Introduction to Knowledge" (1553), to travel "through most parts of Europe." To these the army offered the only possible avenue to clinical experience. Indeed, the fact is that the army was more important in Tudor medical history than the English universities. The handful of university graduates, bred in the literature of Galen, walled round with pride, were not prepared to voyage adventurously in seas that the medieval masters had not charted. A failure to draw a distinction between a Cambridge training and an army experience must always result in a serious misunderstanding of the origins of the few contributions to the enrichment and the stimulation of medical thought in sixteenth century England.

The obvious, or it might almost be said the inevitable, representative of the army men is William Clowes, the Elder. Now Clowes served with Leicester in the Low Countries where "bad surgeons slew more than the enemy." In 1575 he entered St. Bartholomew's Hospital. There he produced some of the best surgical writings of the age, almost unique in that they were more than the usual compilations from authorities, the acceptable "proved practice for all young surgeons." Clowes never sought patients or battled with those who deplored his opposition to orthodox surgical methods—"scornful scanners, their commendations I disdain." Those who know the story of his son's encounter with the impostor Leverett will suspect that the youth inherited something of the uncertain temperament of the choleric father.

With the forces of Henry VIII in 1544 was Clowes's contemporary, Thomas Gale. From the army Gale returned to London to write his "Treatise on Gunshot" (1548) and a small volume on surgery (1563). Meanwhile his famous styptic powder conquered England until Clowes's powder proved more effective, when the public sought the better nostrum.

It is unnecessary here to multiply instances of others, like John Woodhall, who came from the army with unusual technical experience. Of one thing we may be certain. Few Englishmen published tracts that could compare with those of Clowes and Gale, for the latter included their own experiences and their own conclusions.

Far more typical of Tudor medical literature is the work of John Banister or George Baker. Banister delighted in compilations. One of these embraced nine volumes and bore the title "The History of Man Sucked from the Sap of the Most Approved Anatomists" (1578). Baker wrote treatises on pharmacy and distilled medicine and translated pages of Guido, Virgo, Galen and Gessner. Frequently he lapsed into Latin—"I woulde not have every ignorant asse to be made a chirurgion by my book, for they would do more harm with it than good." Even the great Vicary, physician to Henry VIII and Elizabeth, in his "Treatise of the Anatomy of a Man's Body" (1548, 1577, etc.) made no reference to European medical science or to his own experience. The reason for the omissions was an excellent one. Vicary had copied, without acknowledgment, a fourteenth century manuscript. No changes seemed necessary and none were made. His intimate acquaintance with and his affection for Guido de Cauliaco is indicated by a sentence from Vicary's will: "Also I give and bequeath unto the hawle of my company one book called Guido." (This was surely Guido's "Cyrurgia" of 1363 and not his treatise on anatomy.)

IV

In another context it has been suggested that the medical schools in England were still lamentably weak. The great bequest of Linacre had almost no immediate effect upon medical education in Oxford. In the period 1571–1600 Oxford gave only forty-seven medical degrees. Theological contention filled the minds of men in universities still devoted to the traditions of the past. There is also evidence in plenty that medical degrees were often given carelessly. The College of Physicians once complained to Cardinal Pole of the admission of ignorant and unlettered men. Most scandalous were the cases of Ludford, a Franciscan friar who became an apothecary in London, and of Laughton, a coppersmith who could not decline *corpus*.

The academic laws of Oxford seemed rigid enough and doubtless there were periods when regulations were strictly enforced and the lethargic monotony of the university broken. The rules of Oxford declared that the student of medicine and surgery must study six years. He must dispute twice, respond once and see two anatomies before securing his bachelor's degree. He must perform two anatomies and effect at least three cures before being admitted to practice. Yet even had there been no evasions of the college law, Oxford was not England. The best, if not the most famous, of the medical students sought the Continent or the army. So distressing did the situation appear at the middle of the century that a special commission was sent to Oxford by Edward VI with power to assign one college solely to the study of medicine.

In an England where competent and licensed practitioners were few there were many opportunities for unlicensed folk with significant phials to take advantage of the fear and ignorance of the sick.

"Itaque hercule evenit ut cuicumque medicum se professo statim credatur." The sixteenth century, like the twentieth, was confronted with the problem of protecting the gullible. As early as 1511 Linacre probably wrote with his own hand the preamble to an Act of Parliament designed to crumple the quack.

> Forasmuche as the science and connyng of Physyke and Surgerie, to the perfecte knowledge whereof are requisite bothe grete lernyng and ripe experience, ys daily within this Royalme exercised by a grete multitude of ignoraunt persones, of whom the grete parte have no manner of insight in the same, nor in any other kynde of lernyng . . . common Artificers, as Smythes, Wevers, and Women, boldely and customably take upon them grete curis, and thyngis of grete difficultie, in the whiche they partely use socery and whichcrafte, partely applie such medycyns unto the disease as be verey noyous, and nothing metely therefore, to the high displeasure of God, grete infamye to the faculties, and the grevous hurte, damage and distruccion, of many of the Kinges liege people; most specially of them that cannot descerne the unconnyng from the connyng . . . let noo person within the citie of London, nor within VII miles of the same, take upon him to exercise and occupie as a Phisicion or Surgion except he be first examined, approved and admitted by the Byshoppe of London, or by the Dean of Paul's for the tyme beyng, calling to hym or them iiii Doctours of Phisyk and for Surgerie, other expert persones in that facultie. . . . And over thys, let noo person . . . take upon hym to exercise and occupie as a Physician or Surgeon in any Diocese within this Royalme but if he be first examined and approved by the Bisshop of the same Diocese. . . ."

With the assistance of the Church the medical fraternity of London attempted to enforce strict observance of the licensing laws. Their success was not complete, but at least it was far superior to the haphazard and sporadic attempts at control in the country. Rural England became the playground for every type of quack and charlatan.

In 1578, due to concerted action by Linacre and his followers, the charter of the Royal College of Physicians was granted. "The example of well-governed cities in Italy and many other nations" together with the English desire to advance and ensure her medical standards contributed to the foundation of this new Royal College, a college that was on the one side an academy, on the other a gild. It is particularly significant that the six leaders of the infant college possessed foreign medical degrees. In 1522 the power of the college was extended by an Act of Parliament supplementing the Act of 1511. The preamble suggests the continued attempt to crush the amateurs. "It was expedient and necessary to provide that no person be suffered to exercise and practise physic but only those persons that be profound, sad and discreet, groundedly learned and deeply studied in physic." Therefore a monopoly was bestowed upon the college. No person except a graduate of Oxford or Cambridge was to be allowed to practise physic in London unless examined and approved by the college.

Between the physician and the surgeon of Tudor England there was fixed a wide gulf. Physic was a profession; surgery a trade. In 1540 the two companies of the Barbers and Surgeons were united. No barber might practise surgery (except toothdrawing) and no surgeon might shave. The Barber-Surgeons Company was always a poor company, in part because of its rank in the social scale. It is true that the King encouraged the study of anatomy by permitting the Company to dissect a number of bodies from Tyburn's gallows. Yet they were almost equalled in number by the Skinners Company, the Haberdashers and the Fishmongers. Seldom did they succeed in boasting a membership of two hundred. In city processions and gatherings they held seventeenth place. Once they slipped back to twenty-eighth place and once they were ousted altogether. But they had their own ordinances "of the mystery of Barber-Surgeons," as did the famous Barber-Surgeons of York whose rules survive in the Egerton Manuscripts in the British Museum. To enforce their

statutes the London Barber-Surgeons had their own courts. In 1557, according to the Guildhall records, they judged twenty offenders; in 1572 forty-one; in 1599 forty-six. The attempts of the Royal College of Physicians to lift the level of their profession was aided by the Barber-Surgeons, from policy and ambition astute and jealous guardians of the art of surgery.

One of the immediate results of established privilege was the reduction of the number of licensed practitioners. Consequent also upon the fact that the universities produced so few physicians demands arose for remedy. "Since surgeons are so few . . . and London folk fall ill" the Surgeons of London were excepted from service on the Watch, Juries, Constableships through an agreement with the Corporation of London. In 1531 Parliament had enacted that alien surgeons were not handicraft men and therefore not subject to the statutes against alien artificers for exercising handicrafts. A decade later the Barber-Surgeons Company did not enjoy the prospect of alien encroachment and competition. With reluctance bordering on panic they accepted a solution to a knotty problem, contenting themselves with bombast and oblique references to the vicious results of the foreign intrusion. In spite of the fact that "opportunity was taken by the evil-minded to worry alien surgeons" a number came from the Continent to England. After careful scrutiny on the part of the English many of the foreign surgeons were permitted to practise. There were also, of course, physicians from the Continent. In 1541 John Malyard of Normandy demonstrated his excellence before the Royal College of Physicians and was granted leave to work with English patients. In 1542 John Lytster of France was finally allowed to practise when his "cures" became famous, although he had been previously "interrupted therein by the physicians of thys citye because he was not admitted so to do by the Bysshoppe of London, according to the lawe." So, too, Peter Van Duran of Amsterdam finally found the doors hesitantly opened where native physicians and surgeons were too few to serve the city. Jealousy, monopoly and instinctive distrust of foreigners were alike compelled to retreat before the critical necessity of the age.

Late in the reign of Henry VIII it was decided that a part of the difficulty might be overcome if the physicians were permitted to practise surgery. The Royal College, indeed, had been rapidly extending its powers. All the city apothecaries, for instance, had their wares of drugs and medical supplies examined by four representatives of the college. Physicians were finally permitted to practise surgery, but surgeons were forbidden by an Act of Parliament of 1543 to practise physic. "No common surgeons may administer medicine outward . . . for although the most parte of the said craft of surgeons have small coonning, yet they woold take great soomes of money and doo little therefore; and by reason thereof they doo oftentymes impaire and hurte theyre patients, rather than do them goode."

The difficulties that confronted the Royal College of Physicians and the Barber-Surgeons Company in London were not easily surmounted. Regulations alone could not produce complete submission. Evasions of the law were numerous enough; invasions of the city by those who masqueraded as physicians and surgeons made the licensed and competent medical men grow desperate. When George Whetsone wrote his "Touchstone for the Time" to describe the conditions of the Elizabethan London he knew so well he drew down upon himself the wrath of his fellows in the professional circles, in large measure because it was felt his description of slum conditions was unseemly and because he adopted a style reminiscent of John Bales's explosive and indelicate sentences. To them

Whetstone was a "quaint" writer who wrote too much for "the ignorant multitude of people." The learned physicians and the less learned surgeons were troubled even in the citadel of their power.

Without the centers of population the regulations were quite ineffective. Andrew Boorde, in his "Breviary" (*c.* 1542) raised a loud lament. "O lorde, what a great detriment is this to a noble science, that ignorant persones wyl enterpryse to medle with the ministrations of phisicke." Thomas Vicary echoes Boorde in describing the "ignorant practitioners who, not knowing the anatomie, commonly ensure death, and the separation of soule and body."

It would not be difficult to multiply illustrations of the profound sorrow of honest practitioners when they beheld the charlatanry of the villains who deluded the sick and the sound. Such a situation, happily long foreign to the modern age, moved the heart of the splenetic pessimist, Philip Stubbs. With dismay he contemplated a ruined England and anatomized the abuses of a once great profession.

> The good, learned and discreet physicians are necessary and may do much good, so the unlearned and the naughty (as the world is too full of them) may and do much heart daily, as experience teacheth . . . now-a-days every man, tag, and rag, of what insufficiency soever, is suffered to exercise the mystery of physic, and surgery, and to minister both the one and the other, to the diseased, and infirmed persons, but to their woe, you may be sure.
>
> This bringeth the laudable sciences of physic and surgery into hatred, obloquy and contempt, makyth it of no estimation in the world and utterly discrediteth it among men. . . . Great pity it is therefore, that there is such liberty in permitting every one that lust to profane and abuse these venerable sciences of physic and surgery as they do . . . we see a sort of vagrants, who run straggling (I will not say roguing) over the countries . . . they rake in great sums of money, which when they have got, they leave their cures in the dust, I warrant you, and betake them to their heels as their best refuge. . . . Physic is good and yet I would not have every ignorant dolt that knoweth not the use nor benefit thereof, to practise the same.

Even the licensed practitioners came in for the wrath of Stubbs. He denounced those who "rustle it out in the silkes and velvets" for their high charges. He described them as unctuous gentlemen who piously observed, the patient dead, his money gone—"Death is a cruel tiger, who spareth none." He accused them of being in league with the apothecaries who sold "chalk for cheese" and "druggy baggage." Then, too, "as long as money runneth, they will apply gentle and easy potions, medicines and salves . . . but, *deficiente pecunia*, money wanting, they apply bitter potions, nipping medicines, gnawing corrosives, and pinching plasters to grieve their patient withal, thereby to strain out what liquor of life (that is, what money or goods) they are able to give."

It has frequently been observed that in this age of versatility recipes for medicines and strange cures were multiplied. The Galenic theory of the four humours extended deep into the popular mind and was not easily shaken. The belief in supernatural causes and diabolical machinations gave ground but slowly. Henry VIII himself dabbled in medicine, and his plasters and potions were probably as good as the rest. "The King's Majesties own plastre" was made of "the pythe of marshmallowes" and linseed and good white wine. "A certain black plastre devised by the King's highness" was a compound of plantain, violet and honeysuckle leaves mixed with the "fatte of capons" and perhaps was able to "take away inflammacions and cease payne and heale excoriacions." Henry VIII also concocted "decoccioums" and "waters" and through the long records of his court march Dr. Augustyne, Dr. Buttes and Dr. Ayliffe with "a gallon of milke and a quarte of faire water" or "three sweet appuls" or "nightshade, mallowe and violette."

The problems of plague medicine and public health have received more attention from the historian than any other

aspect of Tudor medical history. Most of the literature is well known. All students of the subject are aware that curious preventive measures for the plague ranged from Thomas Cogan's orange a day ("Haven of Health") to Simon Kellaway's "cataplasms" ("A Defensative Against the Plague"). William Bullein, in "A Dialogue Against the Fever Pestilence" (1564), a book less frequently studied than it deserves to be, admits that there are times when "physike cannot prevaile" and yet finds comfort in the fact that there are many potions and powders and perfumes and pills that may be used with some effect against the plague. Here, in an anagram, Dr. Tocrub represents the famous Dr. Burcot, "though a stranger, yet in England for phisicke famous" (Chettle, "Kind-Hart's Dreame," 1593) and Tocrub speaks with ease and knowledge of Galen, Hippocrates and Avicen, declaring to all the importance of the physician. "Honour the physician with the honour that is due unto him because of necessitie, for the Lord hath created him; for he shall receive gifts of the king, yea and of all men." Dr. Tocrub has also certain goodly rules against the plague. "Let all men, women and children avoide out of the evill ayre into a good soyle and then, accordyng to their age, strength of nature, and complexion, let every one of them with some good medicine draw from the body superfluous moisture, and diminish humours, hotte and dry, and use the regiment of diet to drying, sharped with vinegar or tart things, and lesse meates; not so much wyne as they have used in custom; nor angers, nor perturbations of the mind, especially the passion called fear."

The less familiar "Loseley Manuscripts" contain several letters from physician Simon Trippe to patient George More. On September 18, 1581, Trippe wrote: "On Fryday and Saterday the signal will be in the heart, on Sunday, Monday and Tuesday in the stomake, during which tyme it will be no good dealing with yoor ordinary physike untill Wensday come sevennight at the nearest, and from that tyme forwards for 15 or 16 days passing good." In the "Loseley Manuscripts" are also carefully listed "medical receipts and the astrological precautions, some of which are assigned to Master Galien (Galen) leche." A single instance will be sufficiently illustrative. "*For hym that may not slepe:* Take and wryte yese words into leves of lether: Ismael! Ismael! adjuro te per Angelum Michaelum, ut saporetur homo iste; and lay this under his bed, so yt he wot not yereof, and use it allway lytell and lytell, as he shall have need yereto."

V

The most famous of the Tudor medical men, graduates of Continental universities or of the army, were usually found at the court, the hospitals or the universities. The suppression of the monasteries, gilds and chantries (and that event has never been studied sufficiently by students of social history) increased the need for public care of the afflicted poor, for in earlier days the monks had frequently maintained hospitals as part of their foundation. (See especially Conrad Gill, "Studies in Midland History," Oxford, 1930). With the dissolution of the religious houses and with the increase in enclosures the cripples, lepers, discharged soldiers, rogues and beggars trekked desperately into London and other cities. Those with loathsome or contagious diseases were rapidly confined in the lazar-houses at Knightsbridge and Hammersmith and there the warning clang of the leper's bell became daily more familiar.

In 1544 Henry VIII founded St. Bartholomew's Hospital for 100 patients. In spite of a scandal in 1552 in which charges were brought against the Hospital by citizens "having al their zeale in

their tongue only" St. Barts succeeded in accomplishing much good work. When a patient was discharged from the hospital he was given a passport and required to report within a specified number of days at "the place of his nativity" to the mayor or constable. Thus an attempt was made to force the departure of a number of public charges from the city of London.

In 1553 letters patent of Edward VI gave Bridewell to London. Bridewell was in fact a prison-hospital, for the city was ordered to take up and commit to the House of Labour at Bridewell all "idle, lazy ruffians, haunters of stews, vagabonds and sturdy beggars, or other suspected persons whomsoever, and men and women whomsoever of ill name and fame." There at least some of the idle and masterless vagabonds were taken in an effort to abolish beggary in Edward's London.

Edward VI established three other royal hospitals. At St. Thomas' Hospital were kept about two hundred aged and sick (in spite of countless efforts of the inmates to escape). At Bethlehem, due in large part to the work of modest Richard Grafton, conditions were superior to those in other havens. At famous Christ's Hospital the largest endowment of the King found opportunity "for the entertainment of poor distressed and diseased persons till they got well . . . for the maintenance . . . till the age of seven years of all such children whose mothers die in the house." The last and smallest of the London hospitals was Savoy Hospital, suppressed by Edward VI and restored by Mary. For the great city there were no more, and in spite of the work they attempted to do their success, in proportion to the need, was small.

VI

Enough evidence has here been presented to compel the conclusion that the great advances in art and literature and exploration and science in Tudor England were not equalled by the development of medicine. Men were redrawing the world, but the clinical study of disease was just beginning. When there was no English pharmacopeia and the apothecaries still had no charter to sell or purchase drugs, when the men of medicine guarded jealously their medieval secrets, then, certainly, there was no dawn and no renaissance to make its sure and steady way. Even after Mayerne and Gilbert the great Evelyn could speak in praise of the healing qualities of "rain water of the autumnal equinox, exceedingly rectified, very volatile," and John Symcotts, as Professor F. G. Marcham has remarked, could write learnedly of the properties of the mysterious "lohock in the pot." Chaucer, long before, had turned to pen an ironic description of the physic of his own day. It would not, perhaps, have been unfitting in the glorious days of Henry and Elizabeth.

> And certainly where nature will not wirck,
> Farewell, phisike, go bere the corse to chirch.

RELIGION IN A SCIENTIFIC ERA

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I WRITE on the subject of this article in a very humble frame of mind. I am not a professional student of religion nor in any sense am I qualified to discuss either its technical or its deeper philosophical aspects. Perhaps some of the things which I shall say will not be generally approved. But I am venturing to write on this subject because I believe that there are some basic aspects of the much-discussed relationship between science and religion to which the thoughts of both scientists and others can profitably be directed.

For one thing, it is interesting to note the widely contrasting views of able thinkers on this subject. At one extreme is the scientifically minded British philosopher, Bertrand Russell, who said, "My own view on religion is that of Lucretius. I regard it as a disease born of fear and as a source of untold misery to the human race." We must admit some basis for this statement: much of the development of religious doctrines has centered around a desire to escape fears and ills and to gain some advantage. (Parenthetically I should say that these are not unworthy aims, though not on as high a plane as some of the more unselfish aspirations that have motivated religion.) Also we must admit that centuries of warfare, persecution and exploitation in the name of religion have brought "untold misery to the human race."

Quite a different note is struck by another great contemporary thinker, the scientist Robert A. Millikan. He says, "There is no incompatibility between science and the essential purpose of religion, which is to develop the consciences, the ideals and the aspirations of mankind; but individual religions, or branches of religion, often contain more than this essential, and much that is objectionable. Personally I believe that essential and not dogmatic religion is one of the world's supremest needs."

A basic difference in attitude toward religious matters was illustrated by a conversation I had about fifteen years ago with a fundamentalist professor of one of the Christian theological schools. Realizing that we were far apart in our thinking, I tried to see if there was anything on which we could agree; so I asked him two questions which I thought would give us a common starting point. But when he replied I was startled to realize the width of the gulf between this religious leader and practically the entire group of my own acquaintances.

My first question was this: how old is the earth? Attempts have been made, by those who interpret the Old Testament as an infallible historical record of events, to date the origin of the earth on the basis of the seven days of creation plus the genealogical record from Adam and Eve through to the times of ordinary historic record. These estimates come out to be less than 10,000 years.

On the other hand, scientists have numerous methods of estimating geological age. For example, measurements of the rate of erosion of rocks by flowing water indicate that at least hundreds of thousands of years must have been required for the Colorado River to carve out the Grand Canyon. Measurement of the rate of depositing sediment at the mouth of the Nile or the Mississippi similarly points to hundreds of thousands of years as required to produce their great deltas. The same answer

comes from estimates of the time required for the rivers, carrying the salts that are continually dissolved from the ground by fallen rain, to have carried into the oceans the amount of salt that is in them to-day. But most accurate of all is the measurement of the age of rocks by their content of radioactive materials and products. These materials are like tiny clocks, embedded in the rocks and ticking away the centuries entirely unaffected by heat, cold, pressure or chemical combination. Here scientists believe they have an accurate measure of geologic age, and can date rocks in terms of hundreds of millions of years.

In view of this evidence, I said to my theological acquaintance, How can you hold to the literal historical interpretation of the Scriptures as giving a geological age less than 10,000 years? He replied, "You scientists make the assumption, which you can not prove, that the scientific laws which you find true to-day were also true a thousand or more years ago. I prefer to make the assumption that the Holy Scriptures are absolutely accurate." Seeing that I could not reach common ground here, I tried the second question: "Which is more important, the virgin birth of Jesus Christ or his teachings, by word and by example, regarding the attitude that men should take toward their fellow men and toward God?" He replied, "The virgin birth is by far the more important because, if this be not accepted, we have no basis of authority on which to accept his teachings." I tried to argue that the teachings stood on the authority of their own merit, as proven by experience; and that it would seem strange to me to place the ideals which Christ exemplified and to which he devoted his life in a position subordinate to the manner of his birth. But again we could reach no common ground.

In describing this incident I know that I have taken an extreme case. But this present-day illustration is typical of a long evolution in religious thinking. A few thousand years ago nearly every phenomenon of nature was attributed to the act or command of some god or goddess. To-day, instead of praying to gods of wind, rain and sun, we study the reports of the weather bureau, and our meteorologists know the causes and basic laws of the motions of air masses and the formation of clouds and rain. Formerly crops were thought to depend on the degree of benevolence of the goddess of the harvest; to-day we know definitely their dependence on the quality of seed, nature of soil, distribution of sunshine and rain and control of insect pests.

A few centuries ago the idea that the earth is not the center of the universe was held to be a death-blow at the Scriptures, for was it not declared that the sun riseth in the east and setteth in the west, and that the stars run through their orbits? The acceptance of our present astronomical concepts was one of the greatest wrenches in the early Christian Church, for it was the first of a long series of defeats of the then existent ideas of "infallibility and limitless authority" in which the organized church had clothed herself.

A second wrench came with the acceptance of the idea that the earth is spherical. Navigators even before the time of Columbus knew this fact well, though their ideas about the size of the earth were inaccurate. But the church fought this idea, pinning its faith in the biblical phrase, "the four corners of the earth." At one stage in the controversy a queer compromise appeared; maps of the known world were given a shape like a bulging square, or a circle distorted with four cusps, in order to keep the notion of four corners and yet give grudging recognition to the knowledge of navigators and astronomers.

In our own day many of the churches have been fighting a similarly losing

battle against the theory of evolution. Some twenty-five years ago, when my wife was in Y.W.C.A. work, she visited many colleges where the teaching of evolution was forbidden and the name even was mentioned only in whispers. Groups of girls used to request her to meet them off campus and enlighten them as to the meaning of this forbidden subject. And yet for several generations scientists have seen an increasingly clear record of evolution in the age-long development of plants, animals and to some extent of man, as disclosed in the study of skeletons and fossils. But what is more, we are now producing new species of plants and animals in our laboratories, using x-rays or radium or certain chemicals to accelerate processes which have certainly been going on naturally ever since life has existed on this planet. It is even reasonable to expect that this controlled process of evolution may soon be in commercial operation. A number of industrial and agricultural laboratories have been experimenting with it.

All the preceding remarks bear on the much-discussed question: "Is there a conflict between science and religion?" I believe it may be helpful to point out that the answer to this question depends upon the claims of the religion. If a religion essays to make pronouncements regarding the materials, laws and forces of nature, whether laws of physics or astronomy in the inanimate world or laws of biology or heredity in the animate world, then the religion will certainly come sooner or later into conflict with advancing knowledge of science, and will certainly be the loser in the conflict. Those religious persons of fundamentalist leanings may resent this situation, and lay the blame on the upstart scientists of the last hundred years who have rushed in where angels feared to tread. If any feel thus, I would refer them to a *real* fundamentalist of fifteen centuries ago, St. Augustine, who wrote:

> There is some question as to the earth or the sky, or the other elements of this world—respecting which one who is not a Christian has knowledge derived from most certain knowledge or observation: and it is very disgraceful and mischievous, and of all things to be carefully avoided, that a Christian speaking of such matters as being according to the Christian scriptures should be heard by an unbeliever talking such nonsense that the unbeliever, perceiving him to be as wide from the mark as east and west, can hardly restrain himself from laughing.

Permit just one more illustration which aptly bears on St. Augustine's theme. While Benjamin Franklin was making his experiments on the nature of lightning, and his invention of the lightning rod was finding wide and successful use in New England, some of the great clergymen of Boston became greatly exercised over this sinful interference with God's power to strike his wayward children with fear and punishment through thunder and lightning. And when an earthquake shook this region, it was proclaimed from the pulpits as God's warning against such interference with his powers. This attitude by the clergy certainly reduced the respect held both for them and their religion.

On the other hand, science has not encroached upon the basic functions of religion, which have to do with man's aspirations, ideals and motives which guide his emotional adjustment to the world and to his fellow man. Even here science may also play a rôle, through correction of glandular disorders or psychological maladjustments which so often warp man's outlook on life and lead to antisocial or irrational behavior. But, granting all this, I believe that there is a fundamental religious instinct in man that craves expression, and that there is a great realm of spiritual values and satisfactions in which religion and not science has its rôle.

With these observations as a background, let me proceed to a few more positive considerations.

(1) The sources of such conflicts as

have occurred between religion and science are to be found in matters which are really no part of religion. They are either the remanents of old superstitions or are accretions which have become attached to religion like barnacles to a ship. Many of these accretions have come through the efforts of religious men to work out a philosophy of life in all its aspects, and have become ingrained in church doctrines. But, like barnacles, they have impeded rather than aided religious progress. I believe that science has rendered a great service to essential religion in unshackling it from these incumbrances and thus assisting it in developing more clearly its fundamental objectives.

(2) The impact of science on religion has emphasized its dynamic, as opposed to static, character. An extreme example of static attitude is implicit belief in the literal accuracy and permanent perfection of the scriptures of the Jews or the Bible of the Christians. The dynamic attitude is to view those documents as the story of man's continual progress in evolving a religious attitude toward his environment and all that this environment implies. With this viewpoint, grotesque contradictions disappear. We see the evolution of his concept of God from an anthropomorphic conception of numerous deities of capricious behavior and often conflicting purposes, through the notion of a single God who walked and bargained with men, who chastised them and repented, to the conception of a great spiritual force operating through natural laws which are understandable and dependable and at least partly discoverable through science. We see the picture of a continual development in ideas of right and wrong from the early notions of obedience to sets of rules to concepts of social justice and human welfare. We see notions of salvation and eternal life becoming less concentrated on selfish considerations and more concerned with service to others and the permanent contribution of our individual lives to the future welfare of mankind. This dynamic concept of religion as a continually evolving and developing spiritual force is inspiring and acceptable in a scientific world. In my judgment the static concept of religion is sterile, discouraging and unacceptable.

(3) I believe there is justification, and even need, for a variety of religious denominations, which emphasize different aspects of that complex thing that we call the spiritual life. There are two reasons for this belief. The first is that there are many different types of persons: some are emotional, others are severely analytical; some are philosophical, others are active; some like to take initiative and responsibility, others like to be led and directed. So it is natural that there should be churches or other religious organizations where each person can find the type of fellowship and opportunity for expression and activity which will give him the best spiritual satisfaction and development.

A second advantage in having some diversity in religious organizations is that a certain amount of diversity makes for virility and progress. This appears to be true in all aspects of life. It is the diversity of plant life that maintains such life despite diseases and pests which attack and perhaps destroy one or another type. Existence of different types of social organization gives the experience on which sound improvements can be made. In general the tendency for all to herd together makes for safety, conservatism and stagnation, whereas the tendency for expression of individuality leads to risk and progress, though at the expense of some confusion. I suspect that this holds true in religion as in other aspects of life. So, on both counts, I do not agree with some who wish that all religions and churches

might combine under one common faith and doctrine.

(4) A corollary to this last point of view is the need for tolerance and mutual respect between different religious groups. The basis for such tolerance is found in the essential similarity of what I would call the basic objectives and attitudes of all religions. They may differ in emphasis on various points, they may even hold contradictory views on some matters, but all religions worthy of the name possess common ideals of goodness, of unselfishness and service, of reverence for a power which transcends our human strength and understanding. The work of the National Conference of Catholics, Protestants and Jews is a fine example of enlightened effort to stand together for such essentials and to be tolerant and respectful of each other's differences.

(5) In recognizing that religion deals with spiritual interests and values, while science is supreme in the field of observable facts and logical relationships, it is proper to remember that, even in the realm of nature, science has its limitations which are not always appreciated. Science never discovered the ultimate origin or purpose of anything. It can find out *how* the universe works, not what *caused* it or what *determined* the way it works, or its *purpose* or its ultimate *destiny*. If any religion wishes to include a speculation regarding these matters, science can not gainsay her, for these are outside the realm of science. But, in my judgment, they are also outside the proper realm of religion and, being probably incapable of any proof by observation or deduction, are left only to imaginative speculation.

In conclusion, if I were to try to describe the position of religion in a scientific world, I should summarize the situation about as follows:

The entire history of the contact of religion and science shows that the facts of the world and of life which are capable of observation and test constitute a realm in which science is supreme. Science has not supplanted and can not supplant or destroy religion in its proper sense. It can, however, give a setting to which our thoughts on religious matters must conform. Science has continually forced men to take an ever-wider and grander concept of religion by breaking down artificial barriers of ignorance and superstition. Its whole tendency has been to emphasize the fundamentally spiritual character of religion as representing the highest ideals and aspirations of mankind as opposed to theological rules, doctrines, theories, etc. Science has therefore had tremendous influence in shifting the emphasis of religion from the physical to the spiritual world and we must not shut our eyes to the possibility of still further powerful influence of this sort.

Science has thus contributed to the making of religion into a developing, dynamic spiritual force. I believe that the principal influence of science upon religion has been along the following lines. First, to break down "authority" and substitute reason based upon facts of observation. Second, to eliminate superstition and chicanery from religion. Third, to doom any religion of the static type and emphasize the necessity of a continual development of religious thought to keep pace with and interpret the increasing knowledge regarding all matters which pertain to man's activities and environment.

BOOKS ON SCIENCE FOR LAYMEN

DUALISM IN THE MODERN PHYSICS[1]

More than two centuries ago a serious argument arose between the famous Englishman, Isaac Newton, and the somewhat less famous Dutchman, Christian Huyghens. The question was about the physical nature of light, and, whereas Newton was advocating the corpuscular theory, considering light as a flow of a great number of very small particles, Huyghens was of the opinion that we deal here with wave-propagation in a certain all-penetrating medium called the world-ether. The subsequent development of physics led to the triumph of the Huyghens's wave-theory of light, and only in the twentieth century have certain aspects of Newton's point of view come back to the spotlight of physical science. It was indicated by Albert Einstein that the so-called photoeffect-phenomena can be understood only on the basis of the hypothesis that the energy of light is carried through the space in the form of individual energy-packets or light-quanta. Soon after that, the beautiful experiments of Arthur H. Compton have also shown that in the interaction of light with material particles (electrons) it behaves as if it were really formed by individual corpuscles in the old Newton's fashion.

At the same time as the old corpuscular point of view on the nature of light was slowly regaining its position in physics, serious doubts had arisen in the questions concerning the motion of the ordinary material particles. The quantum phenomena of the new physics found their interpretation in the ingenious and revolutionary ideas of Louis de Broglie, who was first to see that these phenomena definitely indicate the presence of certain wave-properties also in the case of motion of ordinary material particles. The experiments of Davisson and Germer gave an excellent proof to these, at first sight, very unusual ideas, showing that a beam of electrons produces the same kind of diffraction-phenomena as an ordinary beam of light-rays.

As a consequence of this new development, modern physics arrived at a certain dualistic point of view, both in the theory of light and in the theory of material particles, and a profound analysis of the situation brought forth a complete change of our most fundamental concepts concerning the nature of motion. Instead of the absolute determinacy characterizing the theories of the classical physics, we are faced now with the new "uncertainty principle" of motion, established and developed by the works of Werner Heisenberg and Niels Bohr.

The book of Louis de Broglie, who was responsible for the introduction of the wave-ideas into the mechanics of material particles, represents an excellent analysis of the development of the "dualistic-crisis" in the modern physics and of its resolution by the present system of physical theory. In the various sections of the book, the author of the wave-theory of matter approaches from different points of view the difficulties arising in the study of the relations between matter and light, and indicates the ways by which these difficulties can be removed. It is a great pity, however, that the book is not written "from the beginning to the end," but represents rather a collection of different separate lectures and addresses cemented together by a number of specially written chapters. This causes a considerable lack of homogeneity of presentation, and whereas some sections are written in a very popular way others require a knowledge of very advanced mathe-

[1] *Matter and Light (The New Physics).* By Louis de Broglie. $3.50. 300 pp. W. W. Norton and Company, Inc., New York.

matical theories. The difference in the time of delivery of various lectures and addresses included in the book causes also such regrettable effects as we find, for example, at the end of the chapter IV2. After discussing for several pages the "extreme obscurity" of the principles of wave-mechanics (the chapter represents an address delivered more than ten years ago), the author makes the footnote indicating that at present the difficulties are removed and that "the interpretation of the New Mechanics in terms given by Heisenberg and Bohr (to be discussed later) has been practically universally accepted."

There is hardly any doubt that much more satisfactory results could be obtained if the author would find the time to write a consistent presentation of the present state of the problem, instead of cementing the book together from different originally unconnected pieces. However, even as it is, the book is very interesting reading, both from the historical and the present points of view.

The technical edition of the book is also very good, except of the picture of the "solar eclipse" (?) appearing for no apparent reason on the jacket.

G. GAMOW

YEARS WITH MORPHEUS[1]

THIS is the first scholarly and complete book on sleep since the appearance of Piéron's in 1913. It contains references to a bibliography of 1,400 titles of more or less learned works—most of them more learned—which have appeared since Piéron or, in some cases, were overlooked by Piéron. Dr. Kleitman's citations are selective, but made with scientific discernment.

Sleep is a subject of wide interest to laymen, but this is not a book for them. It is an important book, however, for workers in the fields of physiology, biology and psychology and is a "must get" for every educational library.

Starting with apparent differences between sleeping and wakefulness, it is found that complete muscular relaxation during sleep is a myth, that blood and circulatory changes are artifacts due to the horizontal posture, that the shunting of blood from the brain in sleep should be a dead ghost.

Then turning to what happens during sleep, lack of uniformity from person to person becomes apparent, and the important fact emerges that "transition" conditions from wakefulness to sleep indicate a continuous rather than a discrete process.

In the following several chapters rhythmic features common both to sleep and wakefulness are considered, showing the apparently basic part of diurnal variations in the cycle of day-to-day life.

Next the experimental possibilities and results of altering these cycles are presented, including such natural interruptions of the cycles as by narcolepsy, epilepsy, sleeping sickness, drugs and hibernation.

In the sections on the hygiene of sleep a confused state of affairs is discovered, perhaps because exceptions outweigh the general rule.

The book concludes with an evolutionary theory of sleep and wakefulness which appears to Dr. Kleitman to reconcile the greatest number of established facts. Being awake is interpreted as having something superimposed on the basic features of sleep; it is individually acquired, not superimposed by cosmic powers, and is chiefly a matter of habit formation and conditioning.

Throughout the book the influence of the fine critical and experimental hand of Professor Anton J. Carlson, with whom Dr. Kleitman works, is apparent, from plain-spoken criticism to Spartan philosophy and emphasis on the machinery of man and animals. Psychoanalysts

[1] *Sleep and Wakefulness.* By Nathaniel Kleitman. Illustrated with charts. $5.00. xii + 638 pp. University of Chicago Press, Chicago, Illinois.

will feel that more attention should have been given to their approach, particularly in the sections on insomnia, dreaming and sleep-walking; we may be confident that their injured feelings will not disturb the author and his co-workers.

DONALD A. LAIRD

REFORMATION OF CRIMINALS[1]

JUDGED by the standards of world history, prisons are a relatively new institution in dealing with criminals; nevertheless, they have been in use for at least a number of generations: a little over two hundred years, to be more explicit. In all this time they have been operated largely on the theory (if any) that if they could be made unattractive and repulsive enough they would, by some strange magic, "deter" the prisoner from further offending or perhaps even "reform" him. Along with many other legal institutions, they have exerted themselves precious little to try to understand the human material with which they deal, and to ascertain by such understanding whether they might increase their efficiency as machines of social defense.

In relatively few localities, and only for a score of years or a little more, has there been an introduction into the scheme of prison management of psychiatry, that specialty of medicine which deals with abnormal conduct. Even this modest intrusion has met with opposition, and only this year New York State, which had developed an outstanding system of prison psychiatry, abolished the work upon the alleged ground of "economy"—an act which may well in the long run reflect itself in increasing recidivism and resulting cost.

The Federal Government, fortunately, has consistently developed in its penitentiaries and reformatories an integration of psychiatry with its program of classification, education and rehabilitation, and it is upon the basis of their experience in this system that the authors have prepared the present volume—in many ways a pioneer in its field.

The authors, employing the classification adopted by the American Prison Association, divide prisoners into six groups, namely: normal, feeble-minded, psychoneurotic, psychopathic, neuropathic and psychotic. There are chapters on each, with a discussion of the definition, the types of reaction and the relationship of the abnormality to crime. The authors point out that feebleminded-ness and psychosis (mental disorder) are not the all-controlling factors in crime that various writers in the past have fancied them to be, but that rather the groups they refer to as psychopathic and neuropathic furnish a substantial number of recruits. On the other hand, they emphasize the existence of influences in the ordinary prison which may conduce to mental disorder, and offer suggestions for improvement in the mental hygiene of the prison. There are chapters on the homosexual prisoner, the recidivist, on discipline in prison and the value of imprisonment. The "Appendix of Landmarks and Dates in the Development of Prisons" is extremely helpful for purposes of orientation. One quotation will serve to indicate the authors' philosophy:

> The reason that imprisonment cannot bring about true reformation lies in the fact that this form of punishment involves a rigid regimentation and outwardly imposed discipline which in the last analysis is nothing but a poorly camouflaged manifestation of force, and reformation can never be forced upon one. It must come from within (p. 263).

The book is written in an eminently practical style, with little recourse to too-technical language. It is, all in all, a volume which should be read by every citizen who has an intelligent interest in the hitherto much-neglected problem of

[1] *Problems in Prison Psychiatry.* By J. G. Wilson, M.D., and M. J. Pescor, M.D. $3.00. 276 pp. Caxton Printers, Ltd., Caldwell, Idaho.

dealing with our convicted offenders. May there soon be more such citizens!

WINFRED OVERHOLSER

"QUEER BIRDS"[1]

AT a time when scientists are too often represented as being magicians, a development of the proposition that they are more or less ordinary human beings is salutary. This volume, which apparently is included in the British "The Library of Science and Culture" series of books, has for its purpose much more than simply maintaining this thesis: it examines the nature of science itself.

The first chapter is directed to the title of the book and reaches the conclusion ". . . that the virtues and vices that the scientist shares with less impressive mortals enter infallibly into the findings of science and affect its reliability," a statement which no scientist would question. Then follows a short chapter with the startling title, "The Unmasking of Logic," which consists only of comments on various recently proposed extensions and modifications of the Aristotelian logic, particularly the rejection of the law of the excluded middle. The next chapter on the characteristics of scientists has more than a slight resemblance to cartoons of them. According to the author, distinguished scientists are solitary geniuses ("queer birds"), physically ailing and subject to mental unbalance. Celebrated scientists are named who are said (probably with some justice) to have had one or more of these characteristics. But it would be easy to select an equal number of distinguished scientists who have the opposite characteristics. A comparative study, with respect to these qualities, of random selections of enough scientists (distinguished), actors, clergymen, newspaper men, physicians, farmers and day laborers to justify statistical conclusions would be interesting and perhaps would dispel the widely held theory that scientists are not really human. If by some chance the American Nobel Laureates in science were selected, the scientists would be represented by men who in respect to urbanity, good health and vigor (both physical and mental), cheerfulness, hopefulness and happiness it would be difficult to surpass. At any rate, it would be worth while to determine whether there is any relationship of introversion and extroversion with "genius."

The fourth chapter has for its thesis the proposition that science is an expression of the social organization. There can be no doubt that science and the social order affect each other profoundly and reciprocally, a fact that inspired the series of conferences on "Science and Society" that have been held at several meetings of the American Association for the Advancement of Science during the past two years, and which are being continued. The difficulties of getting scientific work recognized are greatly exaggerated by the author, and his criticisms of persons in authority who suppress work of their inferiors imply a prevalence of this evil that by no means exists.

The last two chapters in the book on the psychological and philosophical nature of science are admirable and thought-provoking. These chapters not only constitute more than half the book, but from the point of view of penetrating analyses, they *are* the book. Carefully read, they will give the lay reader a new understanding of the essence of science, and no less will they be of interest and value to most scientists. The subjects they discuss are worthy of the careful attention of scientists, psychologists and philosophers.

F. R. M.

[1] *Scientists are Human.* By David Lindsay Watson, with a Foreword by John Dewey. $2.25. xx + 249 pages. Watts and Company, London.

THE PROGRESS OF SCIENCE

AWARD OF THE NOBEL PRIZE IN PHYSIOLOGY AND MEDICINE TO DR. GERHARD DOMAGK

THE 1939 Nobel prize for physiology and medicine has been awarded to Dr. Gerhard Domagk, of the I. G. Farbenindustrie, Wuppertal-Elberfeld, Germany. He is compelled to reject it, but it was eminently fitting that the prize should have been given for the development of Prontosil. Rarely, indeed, has the development of a therapeutic remedy been followed as promptly by so wide-spread a practical application, with such enormous benefits to so many people.

The story of the development of this compound, while still obscure in certain details, is nevertheless fascinating. In 1908 Gelmo prepared para aminobenzene sulfonamide (sulfanilamide). A year later Professor H. Hörlein (at present a director of the I. G.) in conjunction with Dressel and Kothe, prepared sulfonamide-containing azo compounds in a search for dyes possessing a marked degree of fastness to washing and fulling. In 1919 Heidelberger and Jacobs synthesized an azo compound by linking dihydrocuprein with para aminobenzene sulfonamide. This compound was stated to be (along with certain other quinine derivatives) bactericidal in the test-tube, but no further investigation of this property was made.

In 1920, the I. G. Farbenindustrie postulated the preparation of 2:4-diamino azobenzene-4'-sulfonamide, later called Prontosil, in the English patent No. 149,428, but apparently nothing further was done about it until sometime between 1930 and 1932. It must be remembered that the I. G. has always had a lively interest in chemotherapy, and especially so since the discovery of arsphenamine by Ehrlich. Hence, it is not at all surprising that following the first world war, a series of investigations (probably initiated by Professor Hörlein) were carried out in the field of bacterial chemotherapy.

As far as can be ascertained from published reports (which unfortunately are very scant) studies were made in the I. G. laboratories upon the chemotherapeutic effects of certain gold derivatives, hydroquinine preparations, acridine and other compounds. None of these, however, proved to be very effective. Then attention was turned to the azo compounds, especially those similar to the chrysoidins, because it had been claimed that pyridium and selenium possessed chemotherapeutic effects in urinary tract infections.

The synthesis of the azo-compounds was entrusted to Drs. Fritz Mietzsch and Joseph Klarer, and although certain azo dyes prepared by these chemists showed definite bactericidal effects *in vitro*, they were without chemotherapeutic activity *in vivo*. It is at this point that Gerhard Domagk enters the scene. Domagk was born in 1895 at Lagow in Brandenburg. He had just entered the University of Kiel when the first world war broke out, and in October, 1914, he volunteered for the army, in which he served four years. At first he was in a grenadier regiment, but, after being wounded in 1915, was transferred to the medical corps for the remainder of the war.

After the armistice he returned to his studies in Kiel and received his degree in medicine in 1921. In 1924 he was appointed lecturer in general pathology and pathological anatomy at the University of Greifswald. He remained there for a little over a year and then left to become a member of the Pathological Institute at Münster. At this period in his career, Domagk was interested in the effects of x-ray upon the kidney—especially in relation to the production of experimental nephritis.

In 1927, he left Münster to join the staff of the experimental pathological and bacteriological laboratory of the I. G. Farbenindustrie at Wuppertal-Elberfeld, and at the present time he is director of this laboratory. It is only natural to find that after joining the laboratory at Wuppertal, Domagk interested himself in products fabricated by the I. G. Between 1927 and 1935 he seemed mainly concerned (at least in so far as his publications indicate) with a new vitamin A concentrate and the treatment of piroplasma infection in dogs with trypflavin. One of Domagk's duties was to test the chemotherapeutic effects of the various compounds synthesized by Mietzsch and Klarer, and we now know that at least one effective compound was elaborated before Prontosil. The original (and only) protocol of the value of Prontosil in the control of experimental streptococcal infections in mice is dated December 20, 1932. On Christmas day, 1932, Mietzsch and Klarer applied for patents covering not only Prontosil but also several other sulfonamide-containing azo dyes. These patents were granted on the 13th of December, 1934.

However, long before these patents were granted and before Domagk's original paper was published, reports began to appear in the German medical literature regarding the therapeutic effects of Prontosil. The first was read by Foerster on May 17, 1933, before the Düsseldorf Dermatological Society, and it seems from this report that the drug must have been distributed for clinical trial as early as March, 1933.

The February 15th, 1935, issue of the *Deutsche Medizinische Wochenschrift* contained Domagk's original paper on the chemotherapeutic activity of Prontosil in the control of experimental streptococcal infections in mice. In this report he discussed the physical properties of the dye, gave brief data upon its toxicity for animals and described its extraordinary therapeutic effects in mice which had been inoculated with streptococci. He pointed out that the drug was ineffective *in vitro* and that it acted as a true chemotherapeutic agent only in the living animal. In many respects this is the best of the seven communications of Domagk upon the subject of bacterial chemotherapy. In his later papers he frequently seems preoccupied with proving the inferiority of sulfanilamide to the I. G. derivatives of this drug.

This brings us to one of the historical puzzles of bacterial chemotherapy—namely, were the therapeutic effects of sulfanilamide known to the laboratory in Wuppertal-Elberfeld before they were first described by the Trefouëls in France? The only information on this is the statement by Professor Hörlein that sulfanilamide *had* to be brought out in Germany by the I. G. in 1936 because English and French investigators had shown it to be an effective chemotherapeutic remedy.

This, then, is the story of the development of Prontosil. It represents an example of the success which may be obtained when intelligent directing is coupled with unflagging chemical and biological investigations. It is a pity that the I. G. Farbenindustrie could not accept the award which it so justly deserves.

In recognition of his scientific achievements, Dr. Domagk received, however, in 1937, the Emil Fischer Medal, highest honor bestowed by the German Chemical Society, and, in 1939, the Cameron Prize of the University of Edinburgh, Scotland.

Moreover, Dr. Domagk has delivered lectures on recent developments in chemotherapy before learned societies in various countries of continental Europe and in England. He had accepted an invitation to present a paper at the International Congress for Microbiology, which was held in New York last September, but the outbreak of the European war prevented his sailing.

PERRIN H. LONG
THE JOHNS HOPKINS MEDICAL SCHOOL

AMERICAN ASSOCIATION IN ACTION

TWICE a year the American Association for the Advancement of Science holds a meeting, its annual Christmas meeting at the close of December and its summer meeting usually in June. In addition, the Pacific Division and the Southwestern Division of the Association each holds one meeting a year. Therefore, four times a year the Association is in action.

The word "action" implies something alive, at least dynamic. It is no misuse of the word to apply it to the Association during its meetings, for in respect to the number of persons attending them and to the number of addresses delivered and papers presented, these conventions of scientists are notable if not unequaled. The voice of science at the meetings of the Association is not a timid cry in the dark or a despairing wail from the wilderness; it rings with confidence in its methods for obtaining an understanding of the inanimate and the biological worlds, and it expresses in clear tones the hope that these methods may be successfully extended and modified to meet the complex problems of the inter-relations of men. At a time when statesmen stand baffled by the present ills of society and tremble for the future of civilization, scientists, with a background of the long history of life on the earth and of the great progress of man, unafraid and with eager enthusiasm press forward into every accessible unknown region.

If the universe were a chaos there could be no science, for the fundamental basis of science is that natural phenomena recur under similar conditions. A machine will not function unless its parts are constructed and integrated according to some deliberate plan. Similarly, a great scientific organization will not measure up to its responsibilities unless it has clear purposes and adopts appropriate methods for achieving them. One of the functions of the American Association for the Advancement of Science

AIRPLANE VIEW OF THE CAMPUS OF THE OHIO STATE UNIVERSITY.

DR. MARSTON MORSE

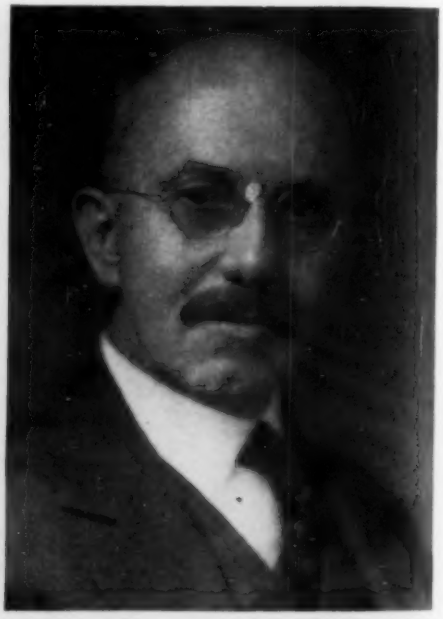
PROFESSOR OF MATHEMATICS, INSTITUTE OF ADVANCED STUDY, PRINCETON UNIVERSITY; CHAIRMAN FOR MATHEMATICS.

DR. ERNEST O. LAWRENCE

DIRECTOR OF THE RADIATION LABORATORY, UNIVERSITY OF CALIFORNIA; CHAIRMAN OF THE SECTION ON PHYSICS. NOBEL PRIZE WINNER, 1939.

DR. HENRY GILMAN

PROFESSOR OF ORGANIC CHEMISTRY, IOWA STATE COLLEGE; CHAIRMAN FOR CHEMISTRY.



DR. EVERETT I. YOWELL

DIRECTOR OF THE CINCINNATI OBSERVATORY; CHAIRMAN FOR ASTRONOMY.

THE PERKINS OBSERVATORY
OF THE OHIO WESLEYAN UNIVERSITY AND THE OHIO STATE UNIVERSITY.

is to integrate the numerous subdivisions of science that have arisen during the past few decades. The extent to which this function is exercised by the Association is indicated by the fact that 169 different scientific societies and organizations are now affiliated with it. These affiliated societies and organizations have a total membership, including duplicates, of nearly a million persons.

At the meetings of the Association there are two kinds of programs, those of such a general character as to be of interest to all intelligent persons and those that consist of technical addresses and papers for specialists. It is through programs of the former kind that the Association becomes most obviously an integrating agency. At no meeting of the Association have its general programs been more interesting and important than those of the meeting which has just been held at Columbus, Ohio. The address of the retiring president of the Association, Dr. Wesley Clair Mitchell, a distinguished economist and professor in Columbia University, was on "The Public Relations of Science." At a time when science is credited by some persons with all progress and blamed by others for all ills, no subject could be more appropriate. The light radiated by science certainly has dazzled a world unaccustomed to such brilliancy. Perhaps

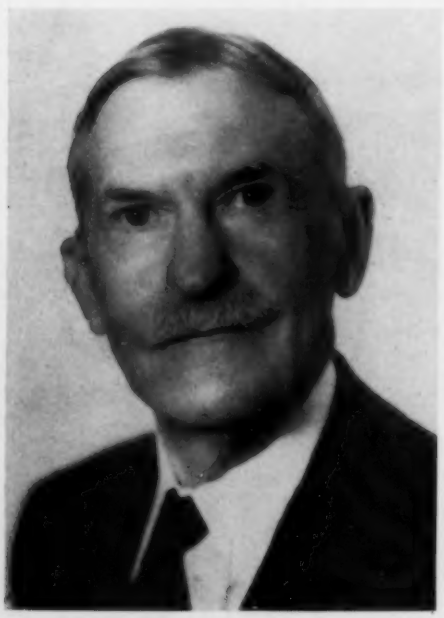
COMMERCE AND ADMINISTRATION BUILDING.
THE BOTANICAL SOCIETY OF AMERICA WILL MEET IN THIS BUILDING.

DR. KIRK BRYAN

SENIOR GEOLOGIST, UNITED STATES GEOLOGICAL SURVEY; CHAIRMAN FOR GEOLOGY AND GEOGRAPHY.

it may become "a pillar of fire" to guide mankind out of the darkness in which it now stumbles.

A little more than a year ago the Association arranged with the British Association for the Advancement of Science for an exchange, on alternate years, of lectures before their respective meetings by distinguished scientists of the two countries. The British chose Dr. Isaiah Bowman, president of The Johns Hopkins University, to deliver the first exchange lecture by an American scientist before the British Association. The meeting at which Dr. Bowman was to speak was scheduled for early September in Dundee, Scotland. With one of the largest registrations in its history and one of its best programs to be presented, German armed forces proceeded by air and land against the Polish people, the British and French Governments declared that a state of war existed between their countries and Germany, and the meeting was completely destroyed. Hearing the news while he was en route to Dundee, Dr.



DR. WESLEY R. COE

PROFESSOR OF BIOLOGY, YALE UNIVERSITY; CHAIRMAN FOR THE ZOOLOGICAL SCIENCES.

DR. NEIL E. STEVENS

PROFESSOR OF BOTANY, UNIVERSITY OF ILLINOIS; CHAIRMAN OF THE SECTION FOR THE BIOLOGICAL SCIENCES.

Bowman stepped off one train, crossed the platform, boarded another train for his port of sailing, "and left the world in darkness and to me (them)." Not permanently in darkness, we have faith to hope, for within ten years after Waterloo did not "Ardennes wave above them (the unreturning brave) her green leaves" again? And will not again the better natures of men prevail?

Although it was expected that a lecture by a British scientist would not be given under the arrangement between the two associations until next summer, the American Association was very fortunate in securing Dr. Julian S. Huxley, of London, to deliver the return address at the Columbus meeting. His subject, "Science, War and Reconstruction," illustrates the sense of responsibility to society that scientists feel and the statesmanship with which they grapple with the acute problems now before the world.

The title of Dr. Huxley's address is arresting, for it implies not only a survey of the present but plans for the future.

DR. CLARK L. HULL

PROFESSOR OF PSYCHOLOGY AT YALE UNIVERSITY; CHAIRMAN OF THE SECTION ON PSYCHOLOGY.

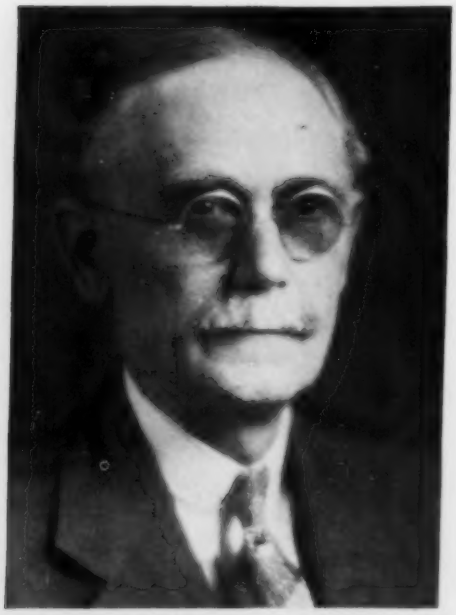
NEIL JUDD

CURATOR, DIVISION OF ARCHEOLOGY, UNITED STATES NATIONAL MUSEUM; CHAIRMAN OF THE SECTION ON ANTHROPOLOGY.

DR. WARREN S. THOMPSON

DIRECTOR, SCRIPPS FOUNDATION FOR RESEARCH IN POPULATION PROBLEMS; CHAIRMAN FOR SOCIAL AND ECONOMIC SCIENCES.

DR. JEROME C. HUNSAKER
HEAD OF DEPARTMENT OF MECHANICAL ENGINEERING, MASSACHUSETTS INSTITUTE OF TECHNOLOGY; CHAIRMAN FOR ENGINEERING.



DR. L. C. KARPINSKI
PROFESSOR OF MATHEMATICS, UNIVERSITY OF MICHIGAN; CHAIRMAN FOR THE HISTORICAL AND PHILOLOGICAL SCIENCES.

Why should not a scientist appraise the forces that are now molding society? They certainly have been produced by science. It is science that has suddenly made all men neighbors, and also competitors for such raw materials as foods, fuels, metals and cellulose. It is science that has provided them with new methods of preserving health by international quarantines, and also placed in their hands new means of destruction. It is science that has enabled one man to talk

DR. CARL J. WIGGERS
PROFESSOR OF PHYSIOLOGY, WESTERN RESERVE UNIVERSITY SCHOOL OF MEDICINE; CHAIRMAN FOR THE MEDICAL SCIENCES.

to millions and to concentrate their energies on a single objective, whether it be peace or war.

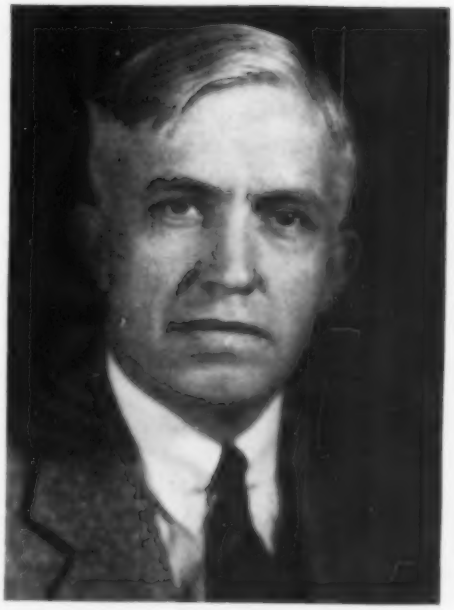
When we remember how generally opinions respecting any important period of the world's history have changed with time, we realize how difficult it is to evaluate the forces that are producing current events. Perhaps scientists, with a background of the history of life on the earth in their minds, and accustomed to the objectivity of science, will be able satisfactorily to appraise the nature of

the forces that are now causing strife in the world. Such an analysis is what Dr. Huxley gives in his address. He does not stop, however, with comments on the present problems of society. Like all thoughtful persons, he anxiously looks toward the future, and he outlines programs for making it better.

The address of Dr. Huxley indicates a great change of point of view since the days of the World War. Then the objectives of both sides were winning the war and punishment for enemies. Now it is recognized that, when the dark clouds of war have passed, the problem before all men will be to set up, in conference, a political organization of Europe that will preserve peace because it is based on sound fundamental principles. As Dr. Huxley states: "But do not let us delude ourselves into thinking that it will be easy. Wishful thinking issuing in impractical schemes is one of man's unique biological attributes."

In its technical programs the Association unites different fields of science to the advantage of all of them. To appreciate these possibilities one has only to think of combined programs in the fields of chemistry and medicine, of education and psychology, of geology and mathematics, of genetics and botany and zoology. To prepare distinguished programs that range across the usual boundaries separating the sciences requires both wide knowledge and imagination. Evidently no one person or small group of persons could cover all science. For this reason the work of the Association is organized under fifteen sections in cooperation with the related affiliated societies. Each section has a chairman, elected for one year, who is a vice-president of the Association. Upon the retirement of these vice-presidents they deliver addresses that are often profound and brilliant surveys of broad fields of science. These are the distinguished scientists whose portraits appear on the pages of this issue of the MONTHLY.

F. R. MOULTON
PERMANENT SECRETARY OF A.A.A.S.



DR. M. R. TRABUE
DEAN OF THE SCHOOL OF EDUCATION, PENNSYLVANIA STATE COLLEGE; CHAIRMAN OF THE SECTION ON EDUCATION.

DR. HENRY SCHMITZ
PROFESSOR AND CHIEF OF DIVISION OF FORESTRY, UNIVERSITY OF MINNESOTA; CHAIRMAN OF THE SECTION ON AGRICULTURE.

ANNUAL RESEARCH EXHIBITION OF THE CARNEGIE INSTITUTION OF WASHINGTON

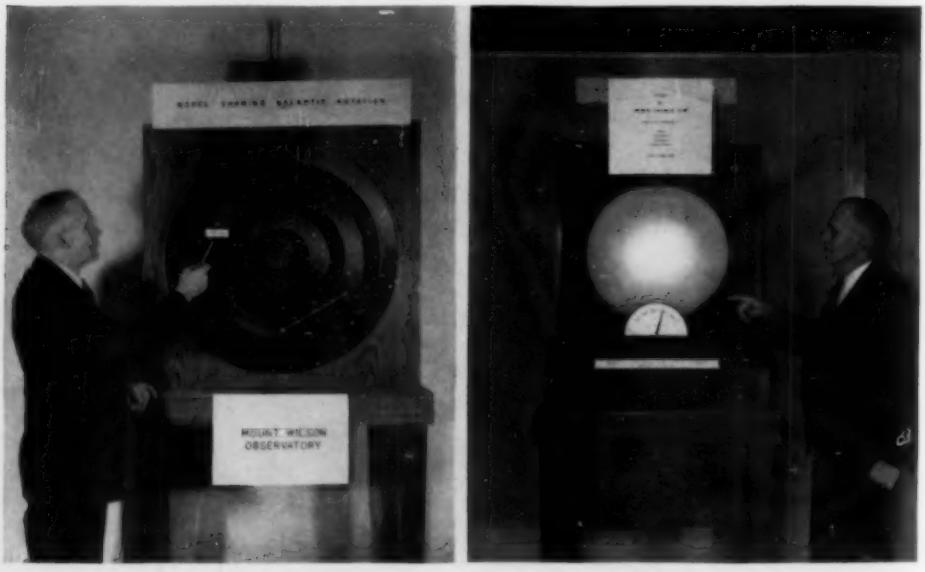
HIGHLIGHTS of some of the most recent scientific researches of the Carnegie Institution of Washington were on public exhibit at its Administration Building, 16th and P Streets, N. W., on December 16, 17 and 18. The exhibits portrayed important discoveries in the fields of animal and plant biology and of the historical and physical sciences. Each exhibit was explained by experts prominently identified with the researches, and short lectures relating to the exhibits were open to the public.

A most unusual exhibit was the one on cosmic rays which, although originating outside the earth and passing through the walls and roof of the building, were actually detected and counted within the exhibit hall. Many photographs were shown to illustrate how the masses, great speeds and electric charges of cosmic rays are deduced.

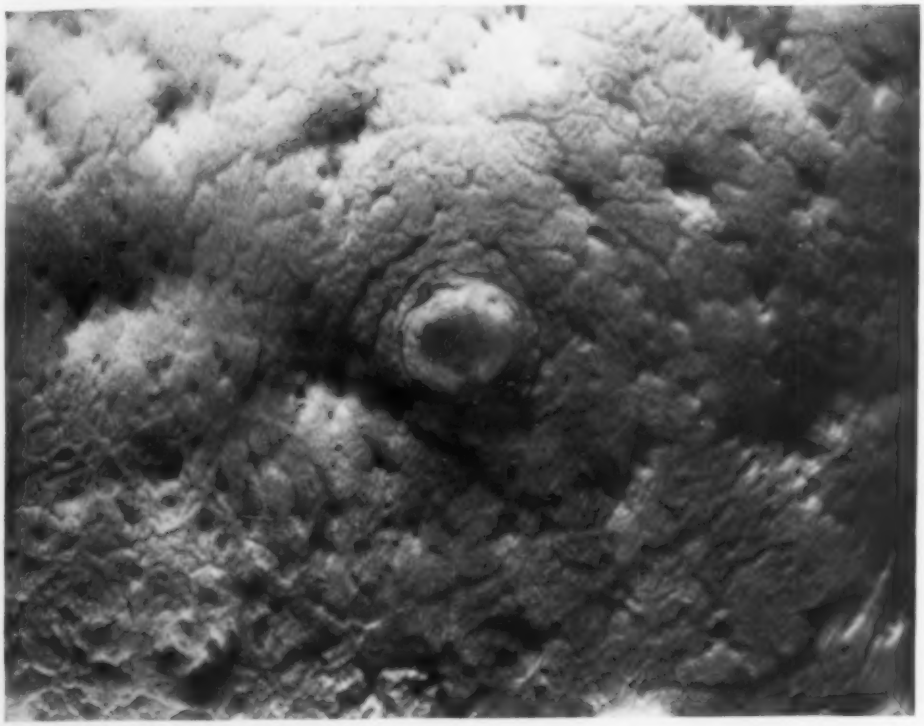
In a demonstration of atom splitting, the uranium atom was broken down to produce other elements such as iodine in forms having the radioactive properties of radium. The important use of the "artificially radioactive" substances thus produced in tracing the course of chemical reactions was explained and illustrated.

Moving models demonstrating the behavior of the magnetic compass and its changes since 1600 were shown in an exhibit dealing with the earth's magnetism. The modification of Columbus' voyage, had he followed present compass directions, illustrated the value of this knowledge. Models showed internal magnets reproducing the earth's magnetism and its changes. Relations of magnetic changes to other natural phenomena were also touched upon.

The exhibit of the Geophysical Laboratory was devoted to its work on the gases in rocks and their relations to volcanic activity and geology. The specimens and charts shown helped to visualize the ways



PROFESSOR A. H. JOY WITH EXHIBIT OF THE MT. WILSON OBSERVATORY.
Left: DEMONSTRATING THE MODEL OF A METHOD FOR SHOWING THE ROTATION OF OUR GALAXY OF STARS. *Right:* DEMONSTRATING A MODEL SHOWING THE VARIATIONS IN DIAMETER AND TEMPERATURE OF A CEPHEID VARIABLE STAR.



SURFACE VIEW OF THE GLANDULAR LINING OF THE UTERUS.

SHOWING EVERYWHERE THE OPENINGS OF THE MOUTHS OF THE UTERINE GLANDS. SOME OF THE GLANDS ARE NOT OPEN. IN THE CENTER IS A PROMINENCE DUE TO THE PRESENCE OF THE OVUM WHICH HAS JUST SUNK BENEATH THE SURFACE. THE MATERNAL EPITHELIUM HAS NOT ENTIRELY HEALED OVER THE TOP OF THE OVUM. THE ACTUAL SIZE OF THE PROMINENCE IS ABOUT 1.0 MM. THE GROWTH OF THE OVUM FROM THIS TIME ON ACQUIRES NEW IMPETUS BECAUSE OF ITS PREDATORY POWERS ON THE MATERNAL TISSUES.

in which gases move about in the earth's crust and the effects of different amounts and intensities of volatiles.

A very striking exhibit of the Division of Animal Biology was the showing of two perfect human embryos approximately eleven days old—the earliest stage of human development which has yet come under direct observation. With the aid of lantern slides and moving pictures, these embryos and the developmental processes which they reveal were described and compared with those in other mammals. Another exhibit of this same division interpreted the results of the transplantation of leukemia in mice of the same and of different genetic constitutions. Protection experimentally induced is effective against leukemic cells which have passed through a long series of transfers from animal to animal, but not against the natural or spontaneous occurrence of leukemia. A third exhibit of this division was of interest to dieticians and others interested in problems of diet because it showed the rates at which various vegetables, fruits, nuts, sugars, etc., are burned in the human body and how quickly their energy contents are made available.

The exhibit of the Division of Plant Biology illustrated, through a number of substances derived from plants, the significance of molecular configuration in living things. The carbon compounds utilized for plant growth exist in two forms identical in chemical composition but differing in the arrangement of atoms

or groups of atoms within the molecules, the differences in arrangements being shown by models. The two forms, which are unsymmetrical, differ from each other as the right hand differs from the left. If the plant is offered food to which it is not accustomed it will starve.

The exhibits of the Mount Wilson Observatory showed the nature and distribution of the pulsating variable stars, illustrating the periodic changes by means of models. Such stars are extremely interesting astronomically, in part their characteristics may be used in the measurements of immense astronomical distances. The exhibit also described and illustrated by diagrams and models the method for showing the rotation of our galaxy of stars. Photographs of other rotating systems were shown. Improvements in the technique of astronomical photography were also exhibited, especially the use of red light for photographing distant stars involved in scattered obscuring materials. By the use of red light numbers of new stars have been discovered that can not be detected by ordinary photography.

The exhibit of the Historical Division showed the successive stages of the growth of an ancient Maya Temple-Palace by means of a series of restored drawings of a ruined temple group at the ancient Maya city of Uaxactun in northern Guatemala, which was excavated by Carnegie Institution. As a result of alterations and additions during the course of several centuries it grew to one of the largest structures in the city.

Stereoscopic projections of color pho-

A CLOSE-UP OF THE OVUM, ENLARGED 300 DIAMETERS.

EARLIEST STAGE OF THE HUMAN EMBRYO EVER OBSERVED. *A:* EMBRYO PROPER; *B:* A PRIMITIVE COB-WEB LIKE TISSUE WHICH "CONDITIONS" THE FLUID IN WHICH THE EMBRYO PROPER IS DEVELOPING—AT THIS TIME ESSENTIALLY A TISSUE CULTURE. *C:* MATERNAL BLOOD CELLS BEING CONSUMED BY THE OVUM. *D:* SHELL OF OVUM ERODING AND CONSUMING THE MATERNAL TISSUES. *E:* EMBRYO-MATERNAL JUNCTION. *F:* MATERNAL TISSUE. *G:* MATERNAL EPITHELIUM HEALING OVER THE POINT OF ENTRANCE OF THE EGGS.

tographs from Yucatan, the surface of the moon and monkey and human embryos were shown at intervals during the exhibit. This demonstration illustrated some of the possibilities of three-dimensional projection as applied to scientific purposes.

T. H. D.

NEW PLANS FOR RELATED ARTICLES IN THE SCIENTIFIC MONTHLY

READERS of THE SCIENTIFIC MONTHLY will recall that several articles have recently appeared in it on each of a number of subjects of importance and wide general interest. For example, during the past year it has published "Religion in Science," by Sir Richard Gregory; "A Scientific Basis for Moral Action," by Professor Max Schoen; and "Does Science Afford a Basis for Ethics," by Dr. Edwin G. Conklin. In about the same period the MONTHLY has also published "Science and Social Values," by Dr. E. V. Cowdry; "Which Way Science," by Dr. Harlan True Stetson; and "Science and the World of Tomorrow," by Dr. Robert A. Millikan.

Plans are now under way for carefully planned articles in various fields. Subjects of importance and of exceptional interest to intelligent persons are selected and each of them is analyzed into a number of unitary subdivisions which together cover the whole field fairly completely. Then a distinguished authority is invited to write on one of each of these subdivisions. The complete series of articles to be published on each subject will constitute a non-technical survey by experts. As a rule only one article on any of these general subjects will appear in an issue of the MONTHLY, and not always will the various ones of a series appear in successive numbers.

Since a concrete example is often more illuminating than an extended description, the plans for the several series of articles that are being developed will be illustrated by the program for those on "Problems of Advancing Age." This subject is among those chosen because the problems of advancing age are ones that every person who is not prematurely struck down by accident or disease must eventually face. Even those who are riding the flood streams of life can rarely escape considering these problems, for everybody has relatives or acquaintances who are entering the shadows.

The problems of advancing age are extraordinarily numerous and varied. For example, the rapidly increasing fraction of the population subject to the ailments and diseases of senescence is shifting the center of interest of medical science. This increase in the relative number of aged presents equally serious problems in connection with all plans for retirements and old-age pensions. In fact, there are repercussions of it in our entire social, economic and political structure.

The following outline for a series of articles on "Problems of Advancing Age" was prepared by Edward J. Stieglitz, M.D., who has already contributed to this particular series in his article on "High Blood Pressure," which appeared in the July, 1939, number of the MONTHLY:

I. General Introduction to the Subject. (Dr. E. V. Cowdry, this issue.)
II. The Biology of Aging.
III. High Blood Pressure.
IV. Mental Changes in Old Age.
V. The Old Heart.
VI. Nutrition and Digestion in Old Age.
VII. Cancer and Old Age.
VIII. Public Health Aspects of Old Age.
IX. Industrial Employment and Old Age.
X. Age and Intellectual Work.
XI. Investment of Leisure in Old Age.
XII. Old Age and the Family Organization.
XIII. Philosophy of the Senescent (by some aged man).
XIV. Philosophy of the Senescent (by some aged woman).

Although each author will treat in his own way the subject he may write upon, Dr. Stieglitz has made an outline of the several topics, primarily to indicate their scope and their relationship to the whole series. In order to illustrate the nature of these outlines, numbers II, VI and XIII and XIV will be briefly summarized.

The Biology of Aging

A. Senescence as a biologic process—its relationship to growth, metabolism, gonad activity, premature senescence, infection, immunity and tumors.

B. Senescence in lower forms of life—experimental studies of low forms, the cell, tissue changes; relation between growth period and normal span of life; factors that advance or retard senescence.

C. Aging in systems of the body—the nervous system, respiratory system, circulatory system, digestive system, glands, skin, balance-control mechanisms.

Naturally the treatment of some of the subtopics of this subject will be considered in other articles. For example, the discussion of the heart will be more extensive in the article on "The Old Heart."

Nutrition and Digestion in Old Age

A. Food and metabolic requirements—nature of requirements and variations with age.

B. Obesity and longevity—statistics on relationship of obesity to longevity, biologic implications, amount and character of food, frequency of eating.

C. Changes in digestive abilities with age—in teeth, stomach, bowels, chemical factors.

D. Sugar tolerance in old age—diabetes incidence, cause, degree, discovery, control; requirements of blood sugar in the aged.

Philosophy of the Senescent

Occasionally a man or a woman attains great age in physical and mental health. Such persons are models and inspirations. Cicero in *De Senectute* most gracefully described their pleasures and satisfactions, but Cicero was not aged (he died at 63) when he wrote his delightful reflections. Perhaps, as Dr. Cowdry has suggested, only the aged know the psychology of the aged; for, although we were all once young, our failure to understand the psychology of children and youths is almost universal. Therefore, the plan for a series of articles on "Problems of Advancing Age" contemplates at least two on the "Philosophy of the Senescent," one by an aged man and the other by an aged woman.

These articles will not be written by persons who have suffered physical or mental misfortunes, or even by those who have been somewhat out of tune with the world, however distinguished they may have been. They will be written, rather, by those who are sailing serenely into a golden sunset. Benjamin Franklin in his later life could have written such an article. So could Elihu Root—they need not be written by scientists. Perhaps it will be found desirable to have more than one person of each sex and from different walks of life interpret for us the psychology of senescence.

Several of the articles of this series will treat of disease, not from any morbid point of view, but because a clear understanding of the hazards of life and how to avoid them is the best insurance for an eventual fullness of years. Guided by scientific knowledge, the goal is useful and happy middle life and mellow old age. Perhaps those who write on "The Philosophy of Senescence" will teach us by precept and example how to live and grow old so that there will "be no moaning at the bar when I (we) put out to sea."

F. R. Moulton